Benthic TMDL Development Stressor Analysis Report

North Fork Catoctin Creek

Loudoun County, Virginia

Submitted by:

Virginia Department of Environmental Quality

Prepared by:

Department of Biological Systems Engineering; Virginia Tech

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Project Personnel

Virginia Tech, Department of Biological Systems Engineering
Gene Yagow, Senior Research Scientist: Project Manager
Brian Benham, Associate Professor and Extension Specialist: Project Director

Virginia Department of Environmental Quality (DEQ)
Jennifer Carlson, Water Resources Planner, Northern Regional Office, Woodbridge
Bryant Thomas, Water Permitting Program Manager, Northern Regional Office, Woodbridge
Liz McKercher, Watershed Programs Manager, Central Office

For additional information, please contact:

Virginia Department of Environmental Quality
Water Quality Assessment Office, Richmond: Liz McKercher, (804) 698-4291
Northern Region Office, Woodbridge: Jennifer Carlson, (703) 583-3859

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1.0 Defining the Cause of Impairment

Basis for Impairment
The lower portion of the North Fork Catoctin Creek was originally listed as impaired due to water quality exceedances of the general aquatic life (benthic) standard in the 2008 Virginia Water Quality Assessment 305(b)/303(d) Integrated Report (VDEQ, 2008). In 2014, an upper portion of the North Fork Catoctin Creek was also listed with a benthic impairment.

The Virginia Department of Environmental Quality (DEQ) has identified the impairment on the lower portion as Cause Group Code A02R-02-BEN, and delineated the benthic impairment as 4.43 miles on North Fork Catoctin Creek (stream segment VAN-A02R_NOC01A00). This impaired segment begins at the confluence of the North Fork Catoctin Creek with an unnamed tributary, located approximately 0.15 river miles downstream from the Route 287 bridge, and continues downstream to its confluence with Catoctin Creek.

DEQ has identified the impairment on the upper portion as Cause Group Code A02R-04-BEN, and delineated the benthic impairment as 2.55 miles on North Fork Catoctin Creek (stream segment VAN-A02R_NOC03A02). This impaired segment begins at the confluence of the North Fork Catoctin Creek with an unnamed tributary, located approximately 0.75 river miles upstream from Route 719 near Hillsboro, and continues downstream 2.55 river miles to an in-stream impoundment formed by Godfrey dam.

The DEQ 2014 Fact Sheets for Category 5 Waters (VDEQ, 2014) state that the lower impaired segment of the North Fork Catoctin Creek was impaired based on assessments of Virginia Stream Condition Index (VSCI) at biological stations 1ANOC000.42; while the upper segment was assessed as impaired based on monitoring at station 1ANOC009.37. The sources of impairment for both segments are listed as “unknown”.

A biological impairment in Virginia is based on the biological monitoring and assessment of benthic macroinvertebrate inventories and a related habitat evaluation. Biomonitoring allows DEQ to assess the overall ecological condition of streams and rivers by evaluating stream condition with respect to suitability for support of aquatic communities. In Virginia, benthic macroinvertebrate communities are used as indicators of ecological condition and are one way to determine support for the aquatic life designated use. A multimetric macroinvertebrate index, the VSCI, is used to assess the aquatic life use status of wadeable freshwater streams and rivers in non-coastal areas of the state. The VSCI combines a series of biological metrics that are regionally calibrated to an appropriate reference condition (VDEQ, 2006a), and combines them into a single value that is sensitive to a wide range of stressors. VSCI values less than 60 are deemed to be impaired, while those equal to or greater than 60 are considered to be healthy.

The data for the bioassessment in North Fork Catoctin Creek were based on DEQ biological monitoring at the two monitoring sites mentioned previously, along with additional monitoring at station 1ANOC004.38, and three citizen monitoring sites that correspond approximately with the three DEQ biological sampling sites, as shown in Figure 1-1. Two additional DEQ ambient monitoring station are also shown in the figure.

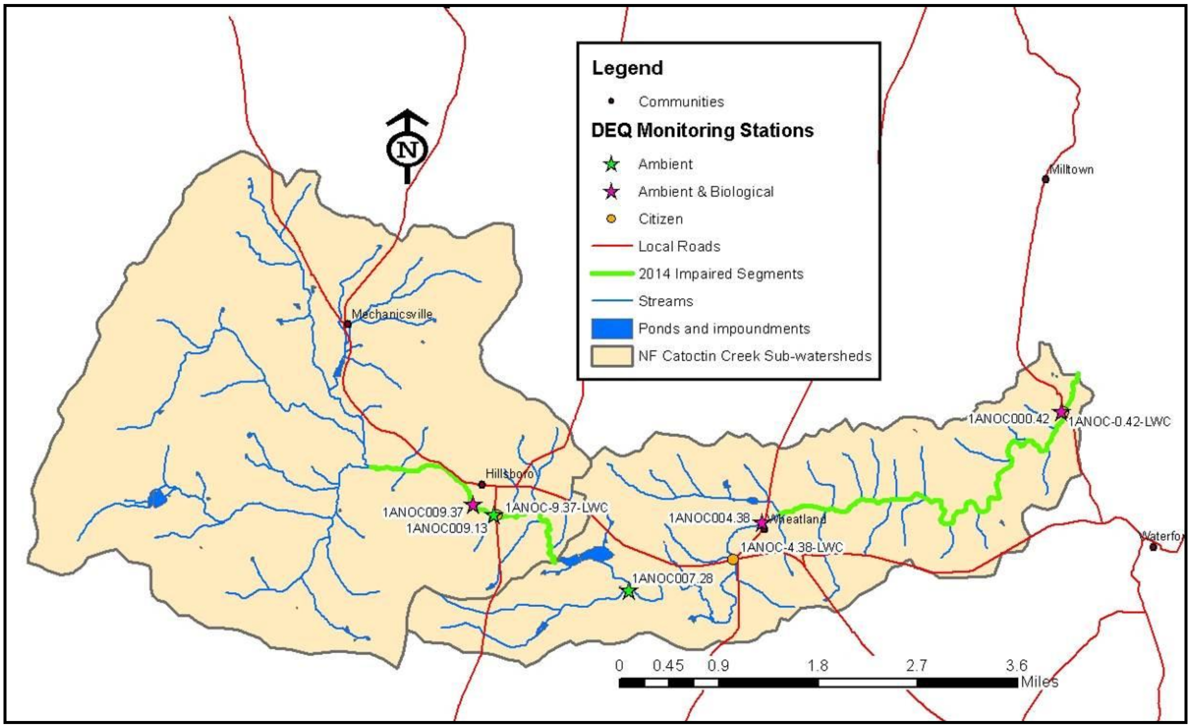

Figure 1-1. DEQ Monitoring Sites in the NF Catoctin Creek Watershed

1.1. DEQ Biological Data

The benthic macroinvertebrates data collected in North Fork (NF) Catoctin Creek by DEQ are summarized in Table 1-1 through Table 1-4. Table 1-1 and Table 1-2 include the inventory of individual taxa and miscellaneous metrics for each sample, at the downstream and upstream stations, respectively.

Table 1-3 and Table 1-4 include the VSCI metric scores and overall ratings. A graph of individual sample VSCI scores for NF Catoctin Creek is shown in Figure 1-2. Table 1-5 includes a description of the individual metrics that comprise the VSCI. The biological monitoring data was provided by the DEQ Northern Regional Office.

The dominant species of benthic macroinvertebrates at all NF Catoctin Creek sites are the pollutant-tolerant chironomidae(A) and Hydropsychidae species (Table 1-1 and Table 1-2), with occasional inclusions of more pollutant-sensitive species. The primary biological effects were assessed as those individual VSCI metrics with scores less than 10. The primary biological effects at the most downstream site in NF Catoctin Creek (1ANOC000.42) are the low scores (%Ephem and %PT-H) for the sensitive members of the ephemeroptera, plecoptera and tricoptera families (Table 1 3), while no primary biological effect was apparent at the intermediate (1ANOC004.38) and upstream (1ANOC0009.37) sites shown in Table 1-4.

Table 1-1. Taxa Inventory for Lower NF Catoctin Creek

Family	Functional Family Group	Tolerance Value	1ANOC000.42											1ANOC004.38			
			06/06/06	12/14/06	05/01/07	04/09/08	11/03/08	03/24/09	10/20/09	05/06/10	11/02/10	10/05/11	11/12/14	10/05/11	04/17/12	12/03/12	11/14/14
Capniidae	Shredder	1		12			3									16	
Perlidae	Predator	1	3		4	2		4		14					1		
Isonychiidae	Filterer	2	25	3	3		2	3	7	27			4		20	7	13
Nemouridae	Shredder	2				4		3									
Perlodidae	Predator	2								1					2		
Taeniopterygidae	Shredder	2		30		1	5						5			36	9
Aeshnidae	Predator	3		1	2		1				1	1				1	
Philopotamidae	Collector	3		2	2		3	2	1			12		4	2		1
Tipulidae	Shredder	3	1	5	2	1	1	2		4	1		1			2	2
Uenoidae	Scraper	3						3								1	
Baetidae	Collector	4	8		6	3			2	19		7		1	20		
Caenidae	Collector	4		4	14			1							5	1	
Elmidae	Scraper	4	2	7	3	4	7	15	6	1		5	5	15	12	2	6
Ephemerellidae	Collector	4			3		1										
Heptageniidae	Scraper	4	2		3		6	1	32	7		11	2	37	10	6	5
Psephenidae	Scraper	4							6	3		12	4	1	2	1	
Corixidae	Predator	5									87						
Corydalidae	Predator	5		2								1		1			1
Dryopidae	Shredder	5		1		1	1		1			3		1	1		
Gyrinidae	Predator	5					1				1			6			
Ancylidae	Scraper	6											17				2
Ancylidae	Scraper	6					1		7					4	2	1	
Chironomidae (A)	Collector	6	3	3	21	62	34	23	7	15	6	2	23		25	6	25
Empididae	Predator	6					4	3									
Hydracarina		6											3				6
Hydropsychidae	Filterer	6	38	12	11	1	30	19	19	9		50	29	33			37
Simuliidae	Filterer	6	2	10	28	13	2	24		1					3	26	1
Lymnaeidae	Scraper	7				6		1			1						
Asellidae	Collector	8			1										1		
Corbiculidae	Filterer	8							1		1				1	2	
Corbiculidae	Filterer	8											3				1
Lumbriculidae	Collector	8		1	2	3			1					2			
Naididae	Collector	8					5	6									
Physidae	Scraper	8	1	1										1			
Tricladida (unknown)	Collector	8							1		3		2				
Chironomidae (B)	Collector	9			2												
Coenagrionidae	Predator	9		1	1				6			1		2			
Lumbricidae	Collector	10			1	1											
Ephemeridae	unknown	unknown										2					
Gammaridae	unknown	unknown												2			
Hydracarina (unknown)	unknown	unknown													2	1	
Hydroptilidae	unknown	unknown											3				
Oligochaeta	unknown	unknown											8				
Sialidae	unknown	unknown										3					
VSCI			49.54	66.02	57.24	36.78	50.59	55.8	64.53	64.08	26.9	56.29	52.64	61.68	66.09	65.38	51.77
Scraper/Filterer-Collector Ratio			0.07	0.23	0.06	0.12	0.18	0.26	1.31	0.15	0.10	0.39	0.46	1.45	0.33	0.26	0.17
% Filterer-Collector			89%	37%	85%	81%	72%	71%	40%	70%	10%	65%	55%	36%	71%	38%	71%
% Haptobenthos			90.6%	36.8%	50.9%	21.4%	48.6%	60.9%	83.5%	66.3%	0.0%	90.9%	55.5%	87.3%	65.5%	40.0%	59.1%
% Shredders			1.2%	50.5%	1.8%	6.8%	9.3%	4.5%	1.0%	4.0%	1.0%	2.7%	5.5%	0.9%	0.9%	49.1%	10.0%

- Dominant 2 species in each sample.

VSCI: Optimal > 60; suboptimal < 50 (VADEQ, 2006).

6 additional taxa were identified with only 1 organism in all samples.

Species with a Tolerance Value of "1" are most sensitive to pollution, while those with a value of "10" are pollution-tolerant.

Table 1-2. Taxa Inventory for Upper NF Catoctin Creek

Family	Functional Family Group	Tolerance Value	1ANOC009.37			
			05/06/10	11/02/10	10/05/11	11/12/14
Capniidae	Shredder	1		2		
Perlidae	Predator	1	3		6	
Isonychiidae	Filterer	2	6	12	43	15
Nemouridae	Shredder	2	5			
Perlodidae	Predator	2	26			
Taeniopterygidae	Shredder	2		3		7
Philopotamidae	Collector	3	3	14	8	2
Tipulidae	Shredder	3				5
Uenoidae	Scraper	3				2
Baetidae	Collector	4	9	1		
Elmidae	Scraper	4	1	7	3	6
Ephemerellidae	Collector	4	11			
Heptageniidae	Scraper	4	12	3	8	13
Psephenidae	Scraper	4	3	2	1	
Corydalidae	Predator	5		2	3	
Ancylidae	Scraper	6				3
Chironomidae (A)	Collector	6	13	23		15
Crangonyctidae	Collector	6		10		1
Hydracarina		6				2
Hydropsychidae	Filterer	6	12	17	38	37
Simuliidae	Filterer	6		3		
Asellidae	Collector	8		3		
Tricladida (unknown)	Collector	8		3		1
Coenagrionidae	Predator	9		1		
Lumbricidae	Collector	10	2			
Oligochaeta	unknown	unknown				1

VSCI	74.67	**59.72**	**55.64**	**59.01**
Scraper/Filterer-Collector Ratio	0.29	0.14	0.13	0.34
% Filterer-Collector	53%	81%	81%	65%
% Haptobenthos	43.4%	55.7%	91.8%	70.9%
% Shredders	4.7%	4.7%	0.0%	10.9%

- Dominant 2 species in each sample.

VSCI: Optimal > 60; suboptimal < 50 (VADEQ, 2006).

Species with a Tolerance Value of "1" are most sensitive to pollution, while those with a value of "10" are pollution-tolerant.

Table 1-3. Virginia Stream Condition (VSCI) Metric Scores – Lower NF Catoctin Creek

StationID	1ANOC000.42											1ANOC004.38			
Collection Date	06/06/06	12/14/06	05/01/07	04/09/08	11/03/08	03/24/09	10/20/09	05/06/10	11/02/10	10/05/11	11/12/14	10/05/11	04/17/12	12/03/12	11/14/14
	Individual VSCI Raw Metric Values														
FamTotTaxa	10	16	19	14	17	15	14	11	8	13	15	14	17	16	14
FamEPTTax	5	6	8	5	7	8	5	6		5	5	4	7	6	6
%Ephem	41.2	7.4	26.4	2.9	8.4	4.6	42.3	52.5	0.0	18.2	5.5	34.6	50.0	12.7	16.4
%PT - Hydropsychidae	3.5	46.3	5.5	6.8	10.3	10.9	1	14.9		10.9	7.3	3.6	4.5	48.2	10
Fam%Scrap	5.9	8.4	5.5	9.7	13.1	18.2	52.6	10.9	1.0	25.5	29.1	52.7	23.6	10.9	12.7
%Chiro	3.5	3.2	20.9	60.2	31.8	20.9	7.2	14.9	5.9	1.8	20.9	0.0	22.7	5.5	22.7
Fam%2Dom	74.1	44.2	44.6	72.8	59.8	42.7	52.6	45.5	92.1	56.4	47.3	63.6	40.9	56.4	56.4
FamHBI	4.4	3.5	5.2	5.7	5.3	5.2	5.0	3.5	5.2	4.9	5.5	5.0	4.2	3.5	4.8
	Individual VSCI Metric Scores														
%Ephem Score	67.2	12.0	43.0	4.8	13.7	7.4	69.0	85.6	0.0	29.7	8.9	56.4	81.6	20.8	26.7
%PT-H Score	9.9	100.0	15.3	19.1	28.9	30.6	2.9	41.7	0.0	30.6	20.4	10.2	12.8	100.0	28.1
%Chironomidae Score	96.5	96.8	79.1	39.8	68.2	79.1	92.8	85.2	94.1	98.2	79.1	100.0	77.3	94.6	77.3
Fam Richness Score	45.5	72.7	86.4	63.6	77.3	68.2	63.6	50.0	36.4	59.1	68.2	63.6	77.3	72.7	63.6
Fam EPT Score	45.5	54.6	72.7	45.5	63.6	72.7	45.5	54.6	0.0	45.5	45.5	36.4	63.6	54.6	54.6
Fam %Scraper Score	11.4	16.3	10.6	18.8	25.4	35.2	100.0	21.1	1.9	49.3	56.4	100.0	45.8	21.1	24.7
Fam %2Dom Score	37.4	80.6	80.1	39.3	58.1	82.8	68.5	78.7	11.5	63.1	76.2	52.6	85.4	63.1	63.1
Fam %MFBI Score	83.0	95.1	70.7	63.4	69.5	70.3	74.0	95.8	71.2	74.9	66.5	74.3	85.0	96.3	76.2
Family VSCI	49.5	66.0	57.2	36.8	50.6	55.8	64.5	64.1	26.9	56.3	52.6	61.7	66.1	65.4	51.8
VSCI Rating	**Stressed**	**Good**	**Stressed**	**Severe Stress**	**Stressed**	**Stressed**	**Good**	**Good**	**Severe Stress**	**Stressed**	**Stressed**	**Good**	**Good**	**Good**	**Stressed**

- Primary biological effects.

Table 1-4. Virginia Stream Condition (VSCI) Metric Scores – Upper NF Catoctin Creek

StationID	1ANOC009.37			
Collection Date	05/06/10	11/02/10	10/05/11	11/12/14
	Individual VSCI Raw Metric Values			
FamTotTaxa	13	16	8	14
FamEPTTax	9	7	5	6
%Ephem	35.9	15.1	46.4	25.5
%PT - Hydropsychidae	34.9	17.9	12.7	10
Fam%Scrap	15.1	11.3	10.9	21.8
%Chiro	12.3	21.7	0.0	13.6
Fam%2Dom	36.8	37.7	73.6	47.3
FamHBI	3.8	4.8	3.7	4.6
	Individual VSCI Metric Scores			
%Ephem Score	58.5	24.6	75.6	41.5
%PT-H Score	98.1	50.4	35.8	28.1
%Chironomidae Score	87.7	78.3	100.0	86.4
Fam Richness Score	59.1	72.7	36.4	63.6
Fam EPT Score	81.8	63.6	45.5	54.6
Fam %Scraper Score	29.3	21.9	21.1	42.3
Fam %2Dom Score	91.3	90.0	38.1	76.2
Fam %MFBI Score	91.6	76.2	92.7	79.5
Family VSCI	74.7	59.7	55.6	59.0
VSCI Rating	**Excellent**	**Stressed**	**Stressed**	**Stressed**

- Primary biological effects.

Table 1-5. Component Metrics of the Virginia Stream Condition Index (VSCI)

Metric	Description	Measures…	Response to Pollution
FamTotTaxa	Number of distinct taxa	overall variety of macroinvertebrate assemblage	Decrease
FamEPTTax	Number of Ephemeroptera, Plecoptera, and Trichoptera taxa	prevalence of pollutant-sensitive mayflies, stoneflies, and caddis flies	Decrease
%Ephem	Percent of individuals Ephemeroptera	pollutant-sensitive mayflies	Decrease
%PT - Hydropsychidae	Percent individuals of Plecoptera, and Trichoptera, excluding Hydropsychidae	pollutant-sensitive stoneflies and caddis flies without counting pollution-insensitive net-spinning caddis flies	Decrease
Fam%Scrap	Percent individuals from scraper functional feeding group	macroinvertebrates which graze on substrate- or periphyton-attached algae	Decrease
%Chiro	Percent of individuals Chironomidae	pollution-tolerant midge larvae	Increase
Fam%2Dom	Percent of individuals from two most dominant taxa	diversity of benthic community	Increase
FamHBI	Family-level Hilsenhoff Biotic Index	average tolerance to pollution of benthic community, weighted by abundance	Increase

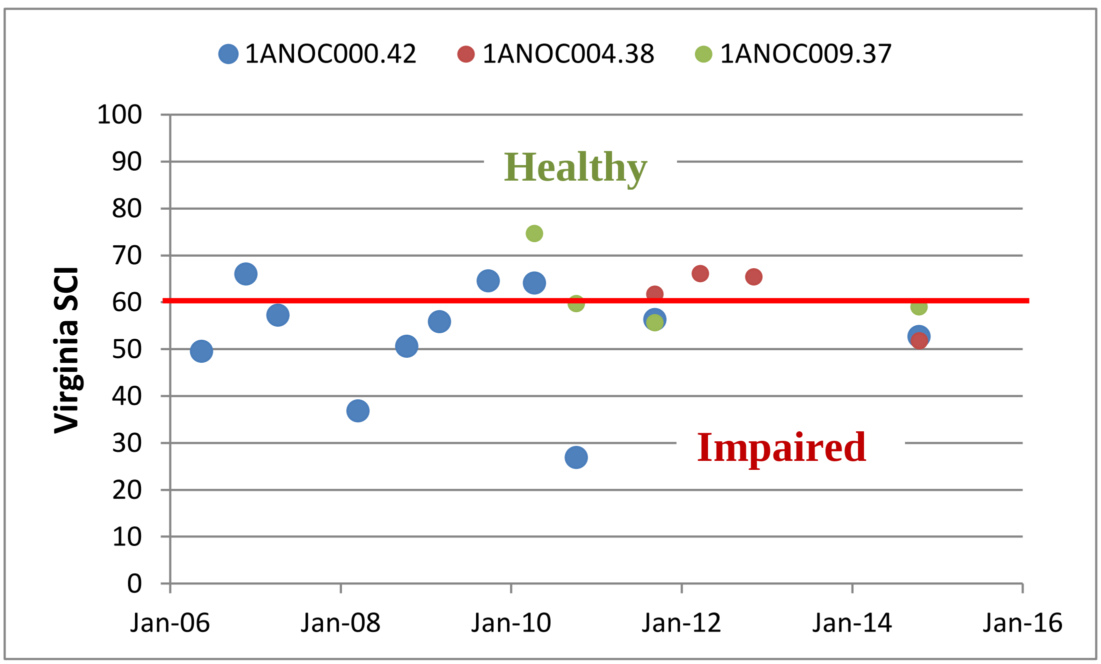

Figure 1-2. VSCI Scores for NF Catoctin Creek

1.2. DEQ Habitat Data

The habitat assessment data for NF Catoctin Creek are shown in Table 1-6 and Table 1-7 for the lower portion and upper portion stations, respectively. Habitat data collected as part of the biological monitoring were also obtained from the Northern Regional Office of DEQ. The 10-metric total possible score is 200; scores less than 120 are considered sub-optimal, and those greater than 150 as optimal. The "bank stability", "vegetative protection", "riparian vegetative zone width" and "sediment deposition" metrics have often received "poor" scores at the lower portion site, while fewer "poor" ratings were given to the upper portion site. While the majority of the scores at the lower portion site have scored in the "sub-optimal" range, none of the scores at the upper site received a "sub-optimal" rating and several were rated as "optimal".

Table 1-6. Habitat Evaluation Summary for the Lower NF Catoctin Creek

StationID	1ANOC000.42											1ANOC004.38			
Collection Date	06/06/06	12/14/06	05/01/07	04/09/08	11/03/08	03/24/09	10/20/09	05/06/10	11/02/10	10/05/11	11/12/14	10/05/11	04/17/12	12/03/12	11/14/14
Channel Alteration	16	17	16	13	16	16	17	19	19	16	18	18	19	18	19
Bank Stability[1]	10	9	9	4	6	4	12	3	6	9	11	12	8	9	10
Vegetative Protection[1]	8	9	5	4	7	4	11	5	7	7	12	13	14	12	16
Embeddedness	17	13	12	13	14	9	14	11	15	12	14	13	12	7	13
Channel Flow Status	13	15	16	18	14	17	16	19	10	20	15	18	11	18	14
Frequency of riffles (or bends)	15	15	13	13	13	11	13	8	9	14	13	10	15	13	13
Riparian Vegetative Zone Width[1]	7	7	6	2	7	7	9	9	7	6	13	12	15	14	18
Sediment Deposition	14	8	10	10	8	7	5	8	8	9	10	13	10	8	11
Epifaunal Substrate / Available Cover	16	16	11	13	13	13	15	13	14	15	12	13	15	10	14
Velocity / Depth Regime	14	13	13	10	10	10	10	13	10	15	15	15	15	13	14
10-Metric Total Habitat Score[2]	**130**	**122**	**111**	**100**	**108**	**98**	**122**	**108**	**105**	**123**	**133**	**137**	**134**	**122**	**142**

- Marginal or Poor habitat metric rating.

[1] Metric is the sum of scores for both the left and right banks.

[2] Total Habitat Score: optimal > 150; suboptimal < 120.

Table 1-7. Habitat Evaluation Summary for the Upper NF Catoctin Creek

StationID	1ANOC009.37			
Collection Date	05/06/10	11/02/10	10/05/11	11/12/14
Channel Alteration	18	18	20	18
Bank Stability[1]	18	15	18	16
Vegetative Protection[1]	18	15	18	14
Embeddedness	14	17	16	12
Channel Flow Status	19	12	17	14
Frequency of riffles (or bends)	19	18	18	18
Riparian Vegetative Zone Width[1]	11	9	12	8
Sediment Deposition	12	17	18	12
Epifaunal Substrate / Available Cover	18	17	18	18
Velocity / Depth Regime	20	10	18	14
10-Metric Total Habitat Score[2]	**167**	**148**	**173**	**144**

- Marginal or Poor habitat metric rating.

[1] Metric is the sum of scores for both the left and right banks.

[2] Total Habitat Score: optimal > 150; suboptimal < 120.

1.3. Loudoun County Biological Data

The benthic macroinvertebrates VSCI metric scores and overall ratings at various NF Catoctin Creek sites were reported by the Loudoun County Department of Building and Development from data collected and analyzed by Versar, Inc. and Biohabitats, Inc. as part of its 2009 stream assessment. For the stressor analysis, the metric data, shown in Table 1-8, were re-scored using the same categories as with the DEQ biological data.

The primary biological effects were assessed as those individual VSCI metrics with scores less than or equal to 10. The primary biological effects at most sites in NF Catoctin Creek watershed were the low scores (%Ephem and %PT-H) for the sensitive members of the ephemeroptera, plecoptera and tricoptera families.

Table 1-8. Loudoun County 2009 Biological Monitoring Summary

Loudoun County Monitoring Site	Upper NF Catoctin Creek				Middle NF Catoctin Creek			Lower NF Catoctin Creek			
	NFCC-109-R-2009	NFCC-206-R-2009	NFCC-313-R-2009	NFCC-325-R-2009	NFCC-305-R-2009	NFCC-308-R-2009	NFCC-303-R-2009	NFCC-316-R-2009	NFCC-320-R-2009	NFCC-323-R-2009	NFCC-319-T-2009
Collection Date	05/12/09	05/12/09	05/12/09	05/26/09	05/13/09	05/13/09	05/13/09	05/12/09	05/12/09	05/26/09	05/13/09
Individual VSCI Metric Scores											
Richness Score	77	82	68	100	100	64	82	100	95	77	64
EPT Score	55	91	45	82	82	36	27	73	73	73	55
%Ephem Score	15	67	43	25	39	7	26	57	16	54	26
%PT-H Score	12	22	5	10	26	3	0	44	24	23	5
%Scraper Score	70	66	37	18	46	43	42	29	40	48	21
%Chironomidae Score	75	88	77	73	79	80	81	79	77	72	50
%2Dom Score	69	68	82	62	94	65	74	93	75	75	56
%MFBI Score	66	88	67	55	74	51	52	81	63	77	67
VSCI	**55**	**71**	**53**	**53**	**68**	**44**	**48**	**69**	**58**	**62**	**43**
VSCI Rating	Stress	Good	Stress	Stress	Good	Stress	Stress	Good	Stress	Good	Stress

- Primary biological effects.

1.4. Loudoun County Habitat Data

The habitat assessment data for NF Catoctin Creek collected by Loudoun County as part of its 2009 stream assessment are shown in Table 1-9 and Table 1-10 for the middle and lower portion, and upper portion stations, respectively. Habitat data collected as part of the biological monitoring were provided through the Loudoun County Water Resources Monitoring Program. The 10-metric total possible score is 200; scores less than 120 were rated "suboptimal", and those greater than 150 as "optimal". Scores in-between these two categories were rated as "fair". The "embeddedness" and "velocity / flow regime" metrics received the most "poor" scores at the upper sites, "bank stability" and "velocity / depth regime" metrics at the middle portion sites, and "bank stability" and "riparian vegetative zone width" at the lower sites. While several scores at the middle and lower sites were rated as "sub-optimal", none of the upper sites received a "sub-optimal" rating.

Table 1-9. Loudoun County 2009 Habitat Evaluation Summary for Middle and Lower NF Catoctin Creek

Loudoun County Monitoring Site	Middle NF Catoctin Creek						Lower NF Catoctin Creek				
	NFCC-107-H-2009	NFCC-302-H-2009	NFCC-305-R-2009	NFCC-308-R-2009	NFCC-303-R-2009	NFCC-306-H-2009	NFCC-303-H-2009	NFCC-316-R-2009	NFCC-320-R-2009	NFCC-323-R-2009	NFCC-319-T-2009
Collection Date	06/12/09	07/09/09	05/13/09	05/13/09	05/13/09	07/09/09	07/09/09	05/12/09	05/12/09	05/26/09	05/13/09
Channel Alteration	19	16	18	18	18	15	18	17	16	18	19
Bank Stability[1]	6	7	8	14	12	11	12	12	8	8	10
Vegetative Protection[1]	6	6	11	18	18	16	17	10	8	12	20
Embeddedness	12	11	15	16	14	12	14	10	10	12	14
Channel Flow Status	17	13	17	16	16	16	15	18	19	13	19
Frequency of riffles (or bends)	18	16	17	17	15	13	16	17	16	16	10
Riparian Vegetative Zone Width[1]	12	12	18	18	18	16	17	2	6	18	6
Sediment Deposition	11	9	14	15	14	11	14	9	14	11	10
Epifaunal Substrate / Available Cover	12	12	17	18	17	15	16	11	16	18	17
Velocity / Depth Regime	10	10	10	13	16	10	15	10	6	13	18
10-Metric Total Habitat Score[2]	**123**	**112**	**145**	**163**	**158**	**135**	**154**	**116**	**119**	**139**	**143**

- Marginal or Poor habitat metric rating.

[1] Metric is the sum of scores for both the left and right banks.

[2] Total Habitat Score: optimal > 150; suboptimal < 120.

Table 1-10. Loudoun County 2009 Habitat Evaluation Summary for the Upper NF Catoctin Creek

	Upper NF Catoctin Creek										
Loudoun County Monitoring Site	NFCC-101-H-2009	NFCC-208-H-2009	NFCC-111-H-2009	NFCC-109-R-2009	NFCC-206-R-2009	NFCC-210-H-2009	NFCC-209-H-2009	NFCC-313-R-2009	NFCC-305-H-2009	NFCC-325-R-2009	NFCC-304-H-2009
Collection Date	06/12/09	06/12/09	06/29/09	05/12/09	05/12/09	07/09/09	07/09/09	05/12/09	06/29/09	05/26/09	06/29/09
Channel Alteration	19	18	16	18	18	15	18	18	11	14	16
Bank Stability[1]	5	14	12	15	14	16	16	14	16	18	14
Vegetative Protection[1]	12	12	16	2	16	17	18	18	10	14	14
Embeddedness	14	10	14	16	16	12	10	8	13	15	14
Channel Flow Status	16	19	10	17	18	16	15	16	16	17	19
Frequency of riffles (or bends)	18	19	19	17	16	16	15	16	16	18	19
Riparian Vegetative Zone Width[1]	12	8	12	2	18	14	18	18	4	13	13
Sediment Deposition	11	11	9	16	16	11	10	11	11	17	13
Epifaunal Substrate / Available Cover	16	15	16	17	17	14	11	15	16	16	15
Velocity / Depth Regime	10	19	10	16	14	10	10	16	15	13	16
10-Metric Total Habitat Score[2]	**133**	**145**	**134**	**136**	**163**	**141**	**141**	**150**	**128**	**155**	**153**

- Marginal or Poor habitat metric rating.

[1] Metric is the sum of scores for both the left and right banks.

[2] Total Habitat Score: optimal > 150; suboptimal < 120.

1.5. Focus of the Investigation

The Investigation's Purpose

The purpose of the stressor analysis is to look for a stressor that was present prior to the earliest bioassessment sampling in 2006, which caused the lower portion of the NF Catoctin Creek's initial 2008 listing on the impaired waters list, and for a stressor prior to 2010, which may have caused the minor impairment in the upper portion of the NF Catoctin Creek. The stressors may be something that either directly affected the benthic community or indirectly affected its habitat. VSCI ratings throughout the NF Catoctin Creek suggest that its benthic community has some stress throughout the system, but the lower watershed may be more stressed than the upper watershed.

1.6. Watershed Characterization

The North Fork Catoctin Creek watershed is part of the Upper Potomac River basin (USGS HUC 02070008) and comprises part of state hydrologic unit A02 (National Watershed Boundary Dataset PL02). North Fork Catoctin Creek is located in Loudoun County. The NF Catoctin Creek watershed is 14,971 acres in size. The major land uses in the watershed are forest, which comprises approximately 45.3% of the watershed, followed by 41.2% in pasture, 7.9% in cropland, and 4.6% in residential land uses. NF Catoctin Creek flows east and discharges into Catoctin Creek, which discharges into the Potomac River. The Potomac River flows into the Chesapeake Bay.

The lower portion of the NF Catoctin Creek watershed is almost entirely located within the Piedmont Uplands (64c) sub-division of the Northern Piedmont (64) ecoregion. The upper portion of the NF Catoctin Creek watershed is split between the Blue Ridge (66) ecoregion along the western and eastern ridges of mountains in this portion of the watershed and the Piedmont Uplands (64c) sub-ecoregion which comprises the valley areas of the upper sub-watershed. The eastern Short Hill Mountains and most of the western Blue Ridge Mountains are located in the

Northern Igneous Ridges (66a) sub-ecoregion, with the most western strip of the watershed located in the Northern Sedimentary and Metasedimentary Ridges (66b) sub-ecoregion. Ecoregion 64c is characterized by rounded hills, low ridges, relative high relief, and narrow valleys and is underlain by metamorphic rock. Ecoregion 66a consists of pronounced ridges separated by high gaps and coves. Mountain flanks are steep and well dissected. Ecoregion 66b is composed of high, steeply sloping ridges and deep, narrow valleys (Omernik and Griffith, 2008).

The NF Catoctin Creek watershed is comprised of a diversity of soils with its dominant soil, Purcellville-Swampoodle complex, only comprising 33.7% of the watershed. The next most abundant soil type is Catoctin channery silt loam at 14.7%, followed by Middleburg silt loam and Purcellville and Tankerville soils at 8.2% and 7.3%, respectively. Soils of the Purcellville series classified as fine-silty, mixed, active, mesic Typic Hapludults, and are very deep and well drained. They formed in residuum derived from diorite, biotite schist, and greenstone schist in the Blue Ridge Uplands. The Catoctin series soils are classified as loamy-skeletal, mixed, superactive, mesic Ruptic-Alfic Eutrudepts, and consist of moderately deep, well drained soils with moderately rapid permeability. They formed in material weathered primarily from greenstone. They are on nearly level to very steep ridges and side slopes. Soils of the Swampoodle series are classified as fine-loamy, mixed, active, mesic Aquic Hapludalfs, and are very deep and moderately well drained. They formed in local colluvium over residuum derived from greenstone schist, biotite schist, and basic gneiss in the Blue Ridge lowlands. The Middleburg series soils are classified as fine-loamy, mixed, active, mesic Ultic Hapludalfs, and consist of very deep, well drained soils formed in colluvium and local alluvium from mixed basic and acid rock materials. They are in upland swales, saddles, heads of drainageways, and on footslopes in the Blue Ridge lowlands. The Tankerville series consists of soils, classified as coarse-loamy, mixed, active, mesic Ultic Hapludalfs that are moderately deep and well drained. They formed in residuum weathered from gneissic and granitic rocks in highly dissected portions of the Blue Ridge uplands (USDA-NRCS, 2012).

Climate data for the NF Catoctin Creek watershed was based on meteorological observations made by the Lincoln National Climatic Data Center station (444909) located approximately 7 miles south of the watershed. Average annual precipitation at this station is 43.2 inches; while the average annual daily temperature is 53.6°F. The highest average daily temperature of 79.0°F occurs in July while the lowest average daily temperature of 21.8°F occurs in January, as obtained from the NCDC 1971-2000 Climate Normals for this station (SERCC, 2015).

Approximately 781 people live in the NF Catoctin watershed, as estimated from the US Census Bureau’s digital file of Block Groups and 2007-2011 population estimates (ACS, 2012). However, based on the number of septic systems currently in the watershed (717), as obtained from the Loudoun County Water Resources Monitoring Program (WRMP) GIS data and an estimate of 2.5 people per house, a better current estimate might be closer to about 1,800 and growing.

Land use categories for the NF Catoctin Creek watershed were derived from the 2012 National Agricultural Statistics Service cropland data layer (USDA-NASS, 2012) for Virginia. Both the lower and upper watersheds are dominated by forest and pasture land uses, with lesser areas in row crop and residential, and a small acreage in other assorted land uses. Broad categories of land use in the watershed are shown in Figure 1-3, while detailed land use is summarized by acreage in Table 1-11.

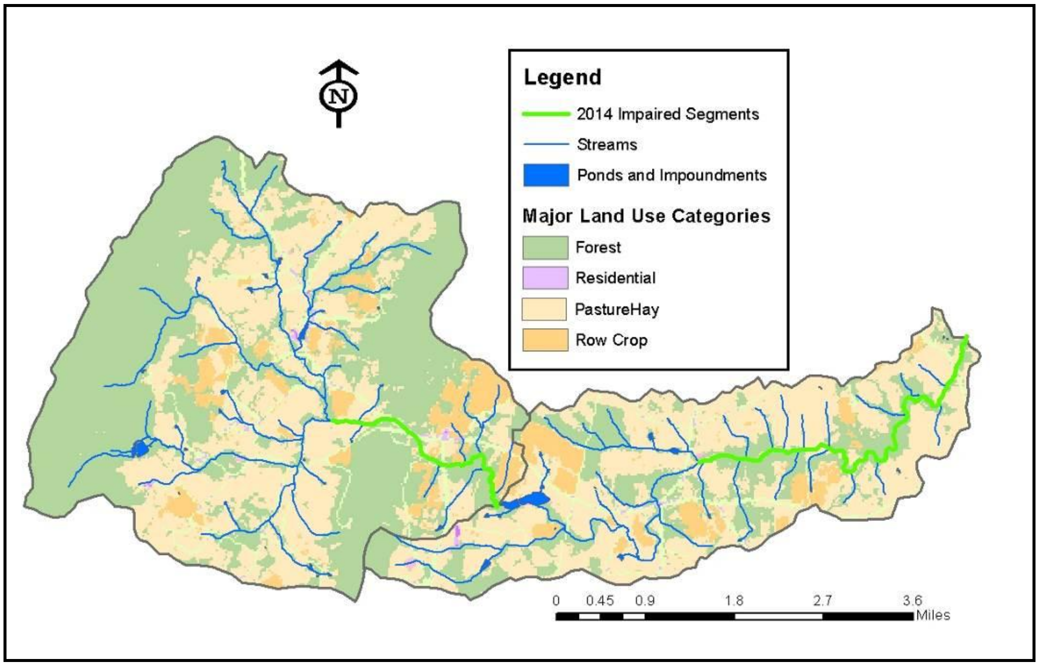

Figure 1-3. NF Catoctin Creek: Broad Categories of NASS Land Use

Table 1-11. NF Catoctin Creek: Detailed 2012 NASS Land Use Categories

NASS Code	NASS Land Use Class	LU Category	Lower	Upper	Total
			Area (ha)		
1	Corn	Row Crop	91.54	169.07	260.61
4	Sorghum	Row Crop	0.27	0.90	1.17
5	Soybeans	Row Crop	62.60	122.81	185.41
21	Barley	Row Crop	2.24	0.54	2.78
24	Winter Wheat	Row Crop	12.42	4.23	16.65
26	W. Wht./Soy. Dbl. Crop	Row Crop	3.61	0.98	4.59
27	Rye	Row Crop	0.09	0.36	0.45
28	Oats	Row Crop	0.09	0.00	0.09
29	Millet	Row Crop	0.00	3.15	3.15
36	Alfalfa	PastureHay	0.61	4.61	5.22
37	Other Pasture/Hays	PastureHay	578.02	640.35	1,218.37
44	Other Crops	Specialty Crops	0.72	0.36	1.08
59	Seed/Sod Grass	Specialty Crops	0.18	0.54	0.72
61	Fallow/Idle Cropland	PastureHay	4.67	8.46	13.13
62	Pasture/Grass	PastureHay	590.65	657.38	1,248.03
68	Apples	Specialty Crops	0.17	1.26	1.43
111	NLCD - Open Water	Water	14.13	9.99	24.12
121	NLCD - Developed/Open Space	Pervious_LDI	105.12	172.73	277.86
122	NLCD - Developed/Low Intensity	LDI	9.73	18.51	28.24
123	NLCD - Developed/Medium Intensit	MDI	0.99	0.99	1.98
131	NLCD - Barren	Barren	0.09	0.00	0.09
141	NLCD - Deciduous Forest	Forest	585.32	2,070.82	2,656.14
142	NLCD - Evergreen Forest	Forest	27.59	48.72	76.31
143	NLCD - Mixed Forest	Forest	2.70	2.61	5.31
152	NLCD - Shrubland	PastureHay	1.60	5.49	7.09
171	NLCD - Grassland Herbaceous	PastureHay	0.44	1.45	1.89
190	NLCD - Woody Wetlands	Forest	3.77	4.14	7.91
195	NLCD - Herbaceous Wetlands	Forest	0.27	0.18	0.45
219	Greens	Specialty Crops	0.00	0.09	0.09
235	Dbl. Crop Barley/Sorghum	Row Crop	0.09	0.00	0.09
237	Dbl. Crop Barley/Corn	Row Crop	0.00	0.27	0.27
254	Dbl. Crop Barley/Soybeans	Row Crop	2.68	1.19	3.87
Total Area (ha):			2,104.50	3,954.30	6,058.80

2.0 Candidate Causes of Impairment

A list of candidate stressors was developed for the NF Catoctin Creek and evaluated to determine the pollutant(s) responsible for the benthic impairment in the watershed. A potential stressor checklist was used to evaluate known relationships or conditions that may show cause and effect between potential stressors and changes in the benthic community. An outline of available evidence was then summarized as the basis for each potential stressor. Depending on the strength of available evidence, the potential stressors were either "eliminated", considered as "possible" stressors, or recommended as the "most probable" stressor(s). Candidate stressors included:

- ammonia,
- pH,
- temperature,
- metals,
- toxic organic compounds,
- nutrients (dissolved oxygen),
- organic matter,
- streambed sedimentation,
- ionic strength (sulfates, conductivity, total dissolved solids), and
- flow/hydrologic modification.

The data used in the evaluation is detailed in Section 3.0, and the evaluation of each candidate stressor is discussed in Section 4.0.

3.0 Data Sources Used in Stressor Identification

In order to investigate and verify the stressor(s) causing the benthic impairment, available bioassessment data, water quality data, special study data, permitted point source data, and ancillary data were examined together with field observations. The extent and content of these data sources are summarized in Table 3-1. Evidence relevant to each candidate cause is summarized in Table 3-2.

Table 3-1. Inventory of Data Used in NF Catoctin Creek Stressor Analysis

Data Type/Location	Stream	Collection Period	No. Samples	Description
Spatial Data				
National Agricultural Statistics Service: 2012 cropland data layer				
Loudoun County WebLogis: potential pollution sources, open space, and floodplains				
Loudoun County Aerial Archives: Godfrey Dam history				
Biological (Benthic) Samples				
1ANOC000.42	Lower NF	06/06 – 11/14	11	DEQ: species counts. Virginia Stream Condition Index (VSCI) scores and ratings. Habitat assessment scores.
1ANOC004.38		10/01 – 11/14	4	
1ANOC009.37	Upper NF	05/10 – 11/14	4	
Ambient Water Quality Samples				
1ANOC000.42	Lower NF	07/79 – 11/14	149	DEQ: ambient physical and chemical water quality data (temp, DO, pH, conductivity, TSS, ammonia-N, nitrite-N, nitrate-N, TKN, TN, TP, *E. coli*, ortho-P, turbidity, chloride, and sulfate.
1ANOC004.38		10/74 – 11/14	78	
1ANOC007.28		02/75 – 11/07	10	
1ANOC009.13	Upper NF	08/79 – 03/00	9	
1ANOC009.37		07/03 – 11/14	14	
1ANOC-0.42-LWW	Lower NF	06/05 – 08/08	140	LWW: *E. coli*
1ANOC-4.38-LWW		07/05 – 03/09	111	
1ANOC-9.13-LWW	Upper	07/05 – 03/09	118	
Other Monitoring				
1ANOC000.42	Lower	05/07, 06/13, 09/13	3	DEQ: dissolved metals in water column.
Various		11/14	3	DEQ: relative bed stability analysis
Various	Lower	06/15	1	DEQ: special synoptic sampling
Various		07/99 – 06/14	8	DEQ: PReP Incidents
Various		2009	22 sites	Loudoun Co.: 2009 stream assessment
1ANOC004.38	Lower	2000 - 2003	4	USDA-NRCS: fish IBI and SVAP
Various		1998 - 2014		VADCR: BMP Installation Data
1ANOC009.37	Upper	2005 - 2006		MWCOG: RSAT data
Various		Dam Inventory	8	DCR
		Water withdrawals	2	Town of Purcellville, Moutoux Orchard
		Well water testing summary		Loudoun County WRMP
Flow Monitoring				
1ANOC000.42	Lower NF	07/01 – 03/15	5002	USGS: daily flow at gage 01638420.
1ANOC007.28		02/12 – 11/12	12	DEQ: monthly measurements of daily

1ANOC009.37	UpperNF	02/12 – 11/12	12	flow
Virginia DEQ Permitted Point Sources				
		Domestic Sewage Permits	5	DEQ: 1000-gpd Single Family Homes
Virginia Household Water Quality Program Household Drinking Water Analyses				
Loudoun Co.	2010 (n=96); 2013 (n=45)	Summaries of household drinking water quality analyses.		

Table 3-2. Evidence Relevant to each Candidate Cause

Candidate Cause	Relevant Evidence
Ammonia	DEQ ambient data
pH	DEQ ambient data, VAHWQP drinking water analyses
Temperature	DEQ ambient data, habitat metrics
Metals	DEQ periodic water column and VAHWQP drinking water analyses
Toxic organic compounds	DEQ periodic water column analyses, permits
Nutrients	DEQ ambient data, DEQ species counts, biological metrics, VAHWQP drinking water analyses, Loudoun Co. WRMP and WebLogis data, DEQ synoptic sampling
Organic Matter	DEQ VSCI metrics, ambient data
Streambed sedimentation	DEQ habitat metrics and total scores, field observations, RBS, SVAP, RSAT, Loudoun Co. 2009 stream assessment
Ionic strength	DEQ ambient data
Flow/hydrological modifications	Daily flow frequency analyses, water withdrawals, dam histories

3.1. DEQ Ambient Data

- Ambient bi-monthly monitoring has been performed on the impaired segment in the lower portion of NF Catoctin Creek at the 1ANOC000.42 ambient station since July 1979 and at 1ANOC004.38 since October 1974. Ambient sampling was performed in the upper portion of NF Catoctin Creek at 1ANOC009.37 primarily in 2003-2005, with a few other occasional recent samples. Short term monthly monitoring was also conducted at stations 1ANOC007.28 and 1ANOC009.13.
- Nutrient data in the NF Catoctin Creek from 2000-2014 are summarized in Table 3-3 to assist in assessing nutrient influences in these watersheds.

Table 3-3. Nutrient Concentration Averages and Ratios at all NF Catoctin Monitoring Stations

Station	TN		NO2+NO3-N		TKN		TP		TN:TP	TKN:TN
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	Ratio	Ratio
1ANOC000.42	1	0.980	16	0.70	16	0.56	16	0.064	15.4	0.44
1ANOC004.38	12	1.162	11	1.00	12	0.48	24	0.047	24.7	0.32
1ANOC007.28	7	1.349	7	0.50	0		7	0.104	12.9	--
1ANOC009.13	0		3	1.07	3	0.37	3	0.023	61.6	0.26
1ANOC009.37	11	1.182	11	0.89	0		11	0.050	23.6	--

* Where TN was not measured directly, Total N was calculated as NO3-N + NO2-N + TKN.

- Plots of monthly water quality monitoring sample data for the ambient monitoring stations on NF Catoctin Creek are shown in Figure 3-1 through Figure 3-16.
- Where applicable, minimum and/or maximum water quality standards, minimum detention limits (MDL), and sample analysis caps are indicated on the plots. All stream segments within these watersheds are Class III Non-Tidal Waters (Coastal and

Piedmont Zones; 9VAC25-260-50). The portion of upper NF Catoctin Creek and its tributaries from Purcellville's raw water intake to its headwaters are designated as a public water supply (PWS).

- Field physical parameters include temperature, pH, dissolved oxygen (DO), and specific conductivity. Chemical parameters include total suspended solids (TSS), ammonia-N, nitrite-N, nitrate-N, total Kjeldahl nitrogen (TKN), total nitrogen (TN), total phosphorus (TP), *Escherichia coli* (*E. coli*) orthophosphate-P, turbidity, chloride, and sulfate.

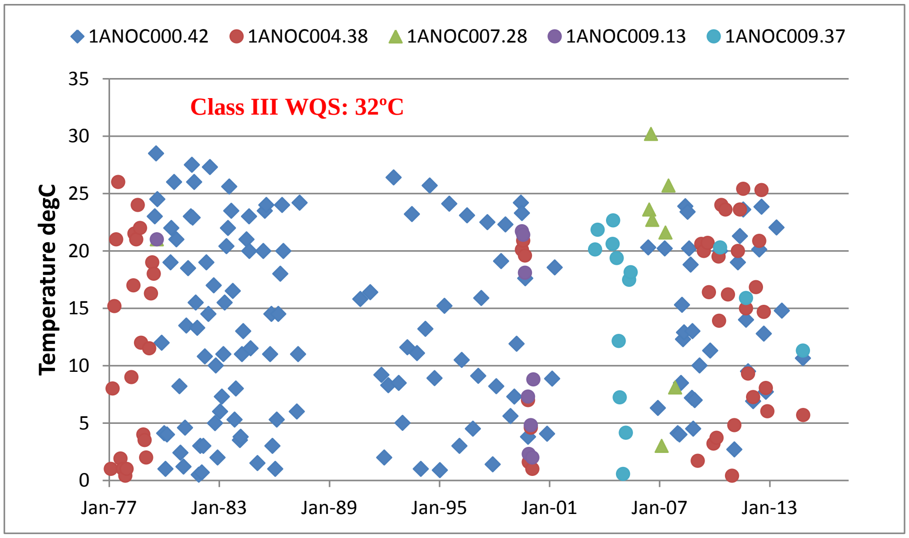

Figure 3-1. Field Temperature

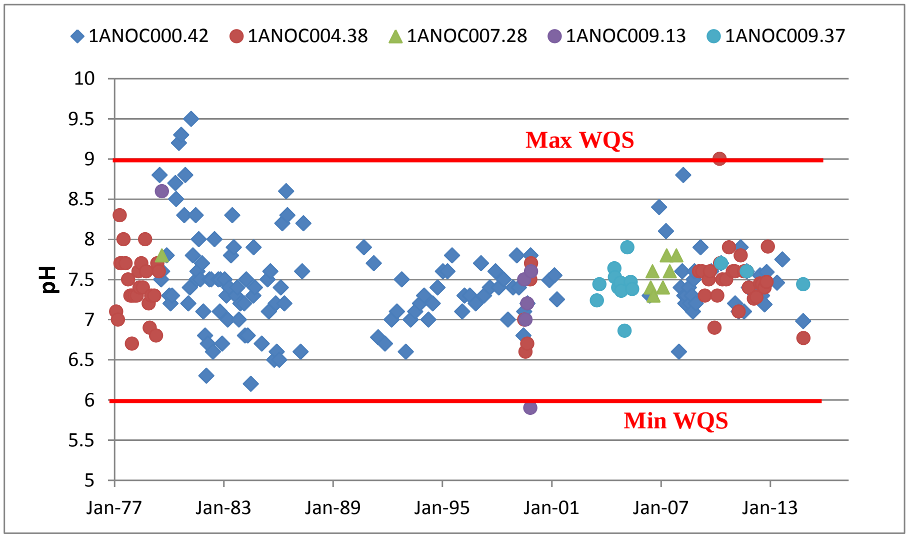

Figure 3-2. Field pH

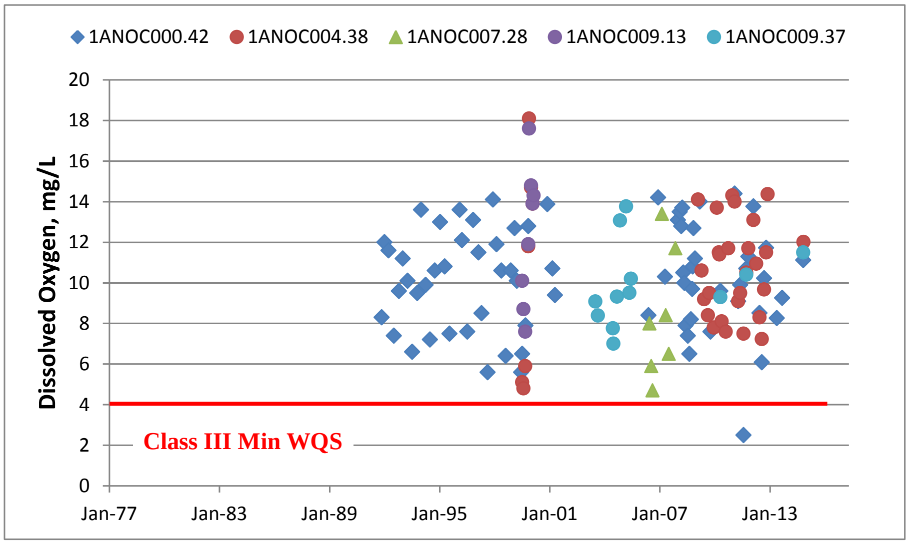

Figure 3-3. Field Dissolved Oxygen

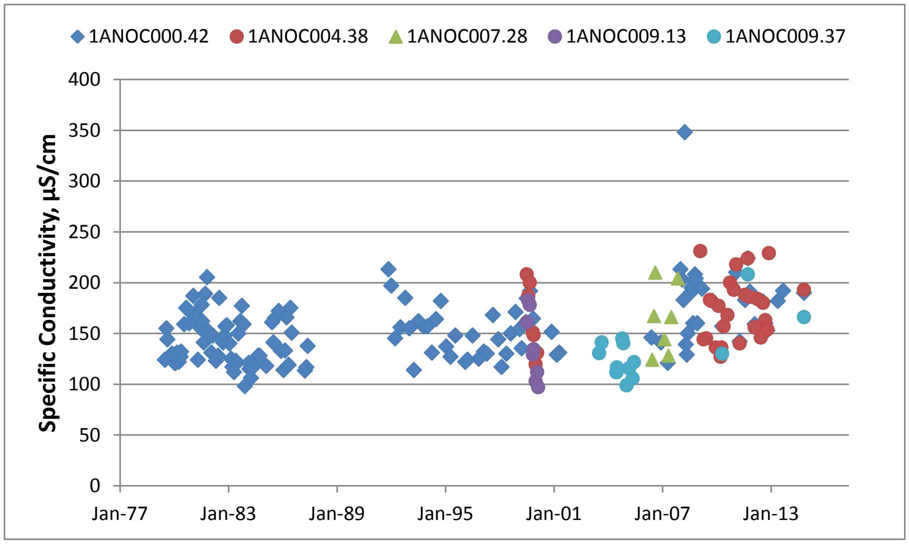

Figure 3-4. Field Conductivity

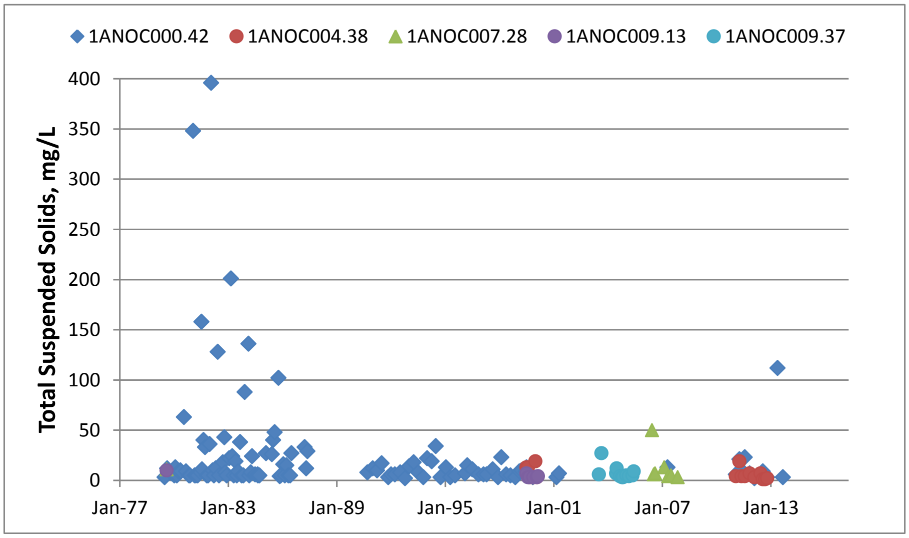

Figure 3-5. Total Suspended Solids

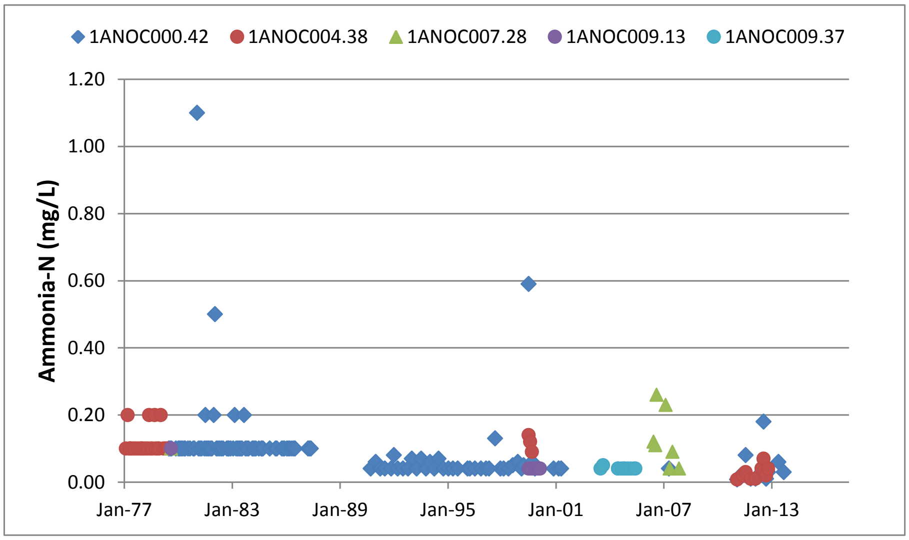

Figure 3-6. Ammonia-N

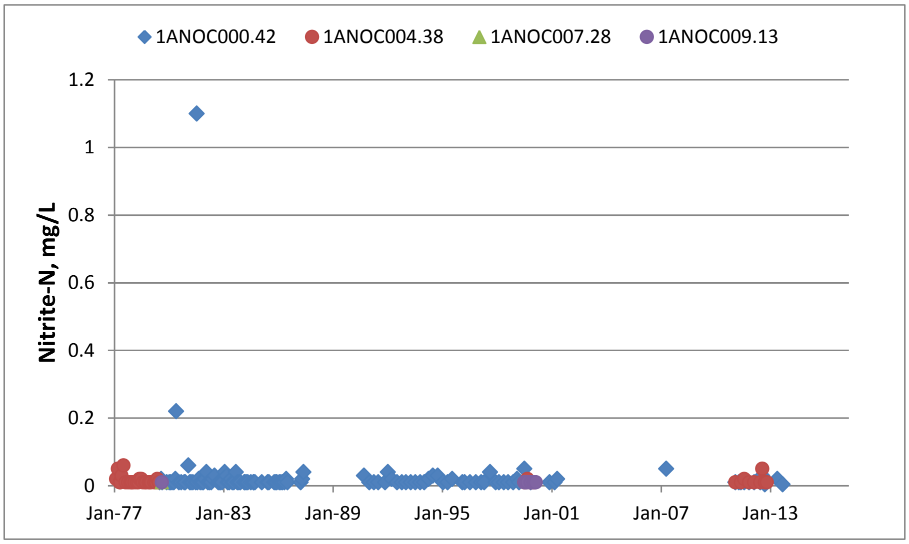

Figure 3-7. Nitrite-N

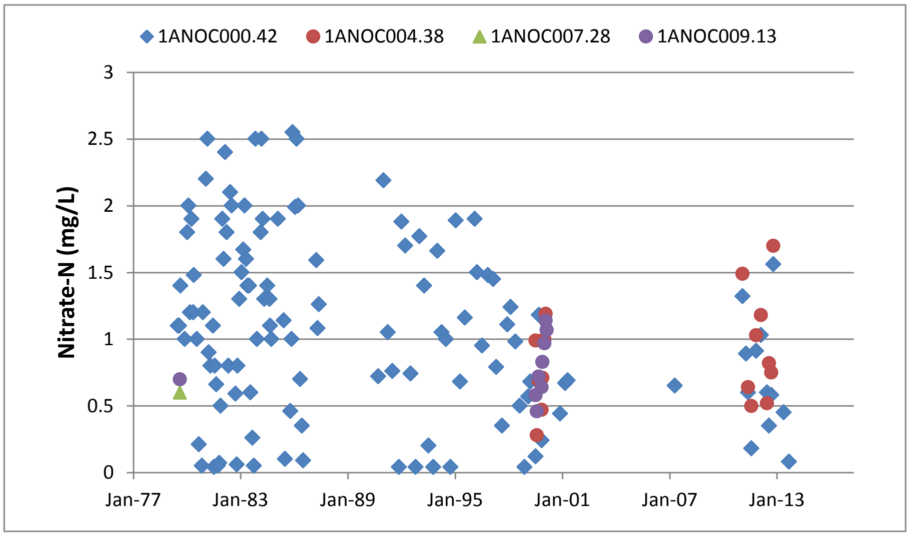

Figure 3-8. Nitrate-N

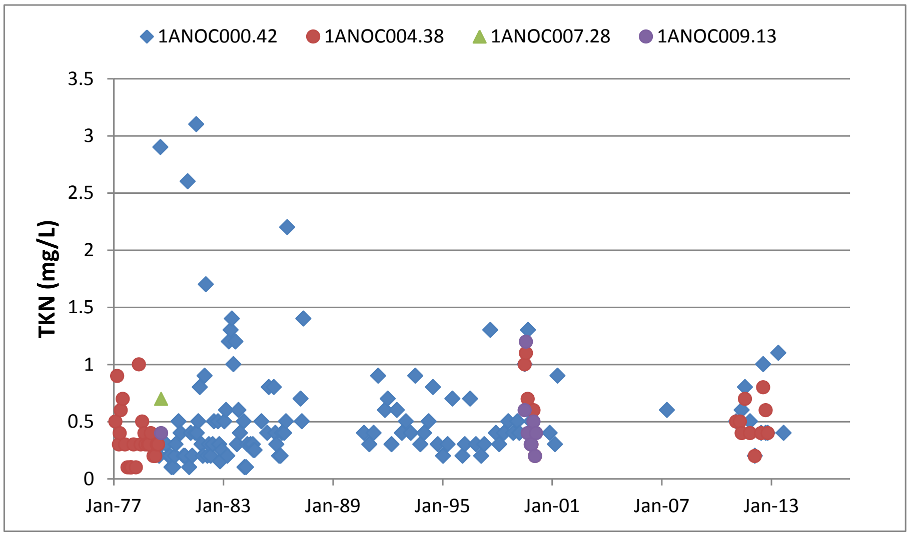

Figure 3-9. Total Kjeldahl Nitrogen

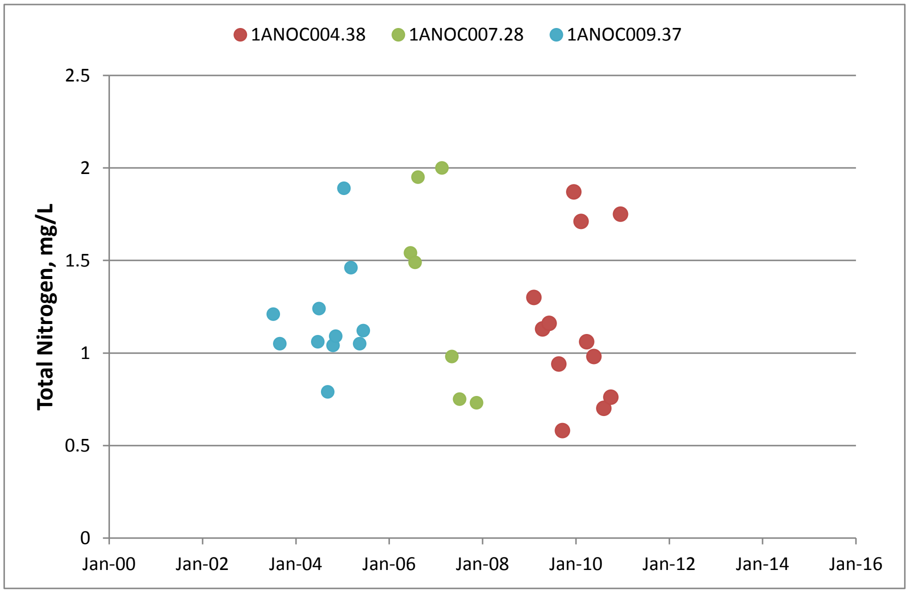

Figure 3-10. Total Nitrogen

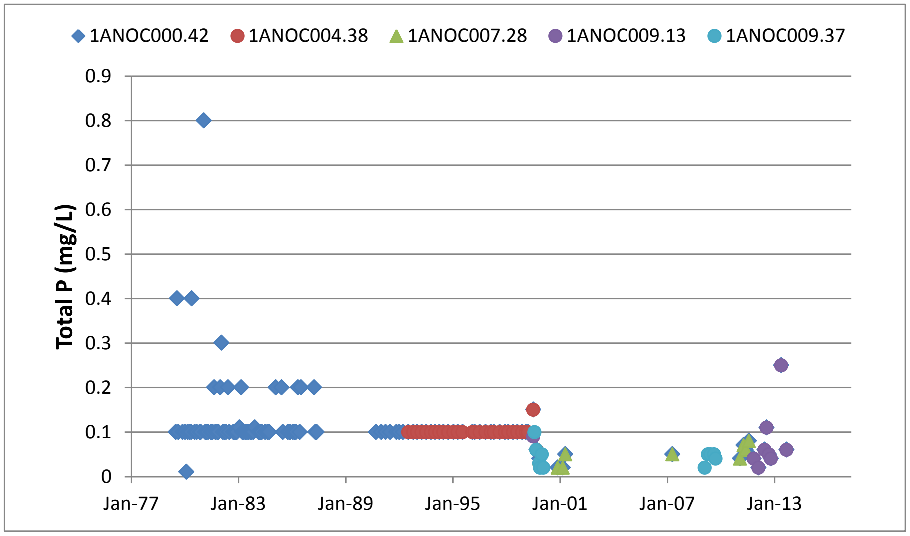

Figure 3-11. Total Phosphorus

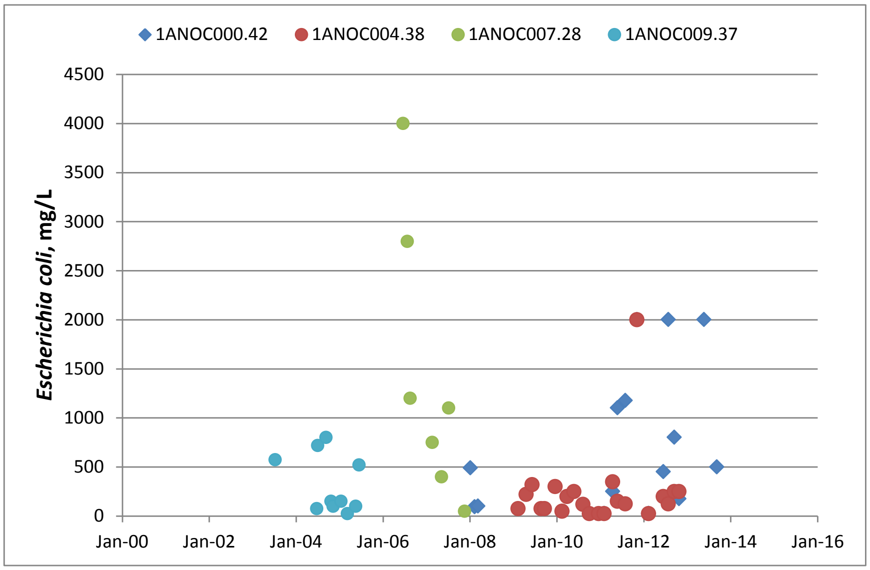

Figure 3-12. *Escherichia coli*

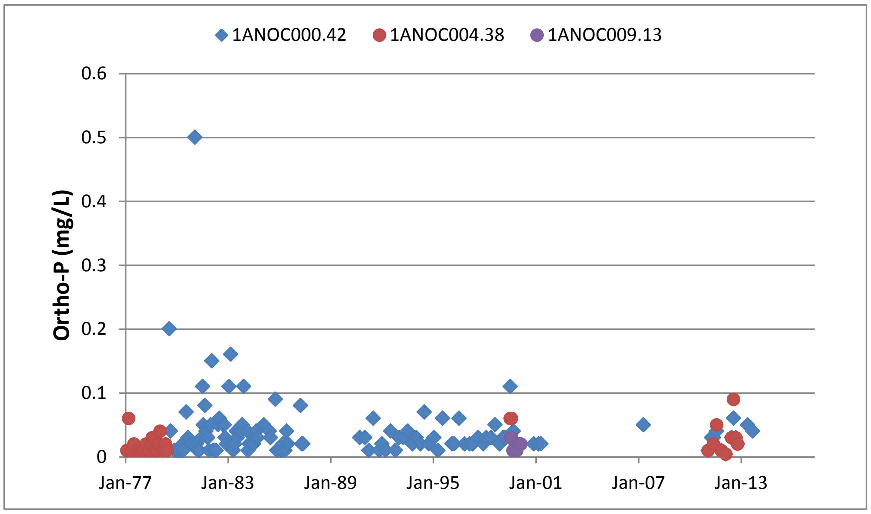

Figure 3-13. Orthophosphate-P

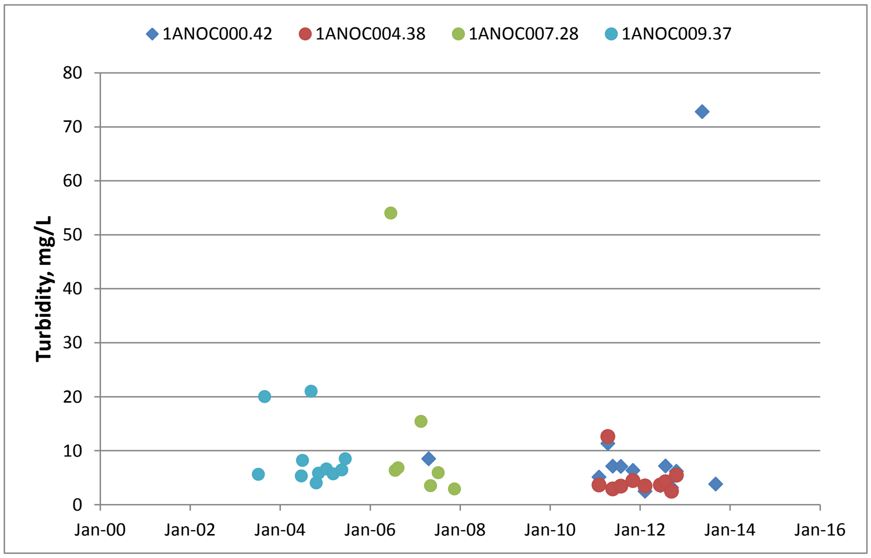

Figure 3-14. Turbidity

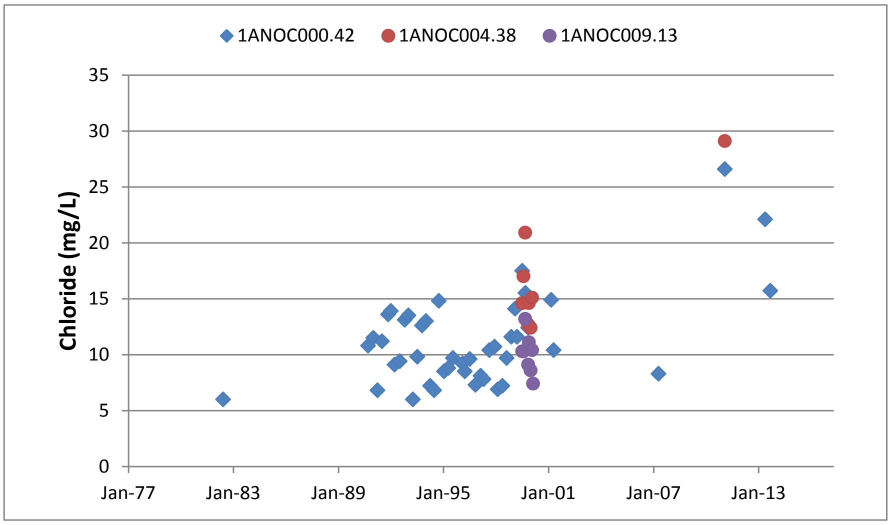

Figure 3-15. Chloride

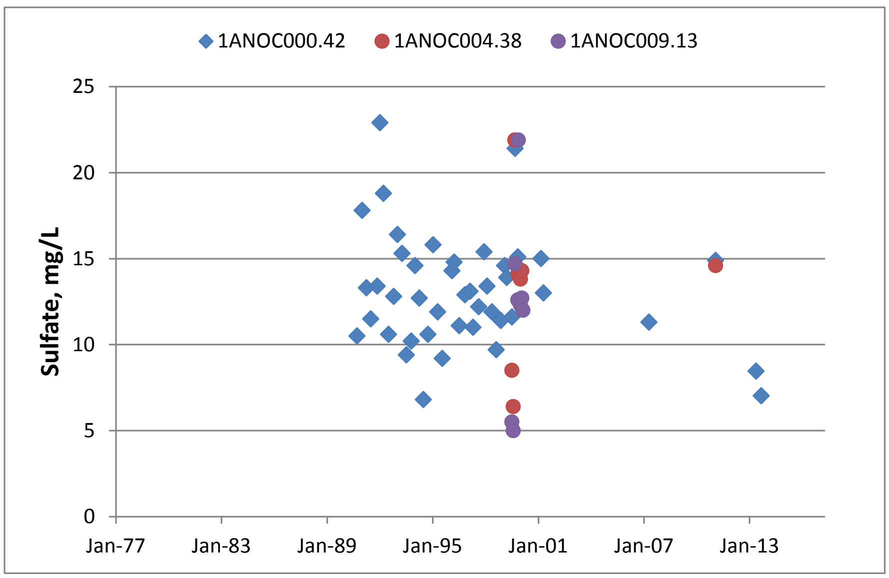

Figure 3-16. Sulfate

3.2. DEQ Stream Tests for Metals and Organic Compounds

- Samples were analyzed for dissolved metals on two different dates in 2013 at station 1ANOC000.42. One historic sample (2007) is also shown, although the full suite of dissolved metals was not analyzed. These results are shown in Table 3-4. No samples exceeded any of the applicable aquatic life, human health, or EPA nationally recommended freshwater criteria.
- Heavy metals such as mercury, chromium, cadmium, arsenic and lead in streams and rivers can damage aquatic insects at low concentrations. The metals tend to accumulate in the gills and muscles of aquatic organisms. Dissolved metals have been identified as important predictors of stream health. In the context of water quality criteria, dissolved metals are typically treated independently; however there is strong evidence that metals have a cumulative effect (Clements et al., 2000). The Cumulative Criterion Units (CCU) metals index accounts for this additive effect by standardizing each dissolved metal's concentration. The metals are summed together

and the result is the CCU Metals Index score. When the CCU Metals Index is above 2, the cumulative effect is considered likely to harm aquatic life (Clements et al., 2000). The CCU scores for these set of dissolved metals were 0.50 on 06/03/13 and 0.68 on 09/19/13, both well below the threshold of concern.

Table 3-4. Dissolved Metals Monitoring and Screening Criteria

Parameter Code	Parameter Name	1ANOC000.42					Aquatic Life Freshwater Criteria		Human Health Criteria	
		05/01/07	06/03/13		09/19/13					
		Value	Value	Comment Code	Value	Comment Code	Acute (µg/L)	Chronic (µg/L)	Public Well Supplies (µg/L)	Other Surface Waters (µg/L)
00915	CALCIUM, DISSOLVED (MG/L AS CA)	16	10.3		15.7					
00916	CALCIUM, TOTAL (MG/L AS CA)	-	13.3		14.8					
00925	MAGNESIUM, DISSOLVED (MG/L AS MG)	4.94	4.12		6.53					
00927	MAGNESIUM, TOTAL (MG/L AS MG)	-	5.66		6.3					
00930	SODIUM, DISSOLVED (MG/L AS NA)	7.63	-		-					
00935	POTASSIUM, DISSOLVED (MG/L AS K)	1.41	-		4.18					
00937	POTASSIUM, TOTAL MG/L AS K	-	-		3.87					
01000	ARSENIC, DISSOLVED (UG/L AS AS)[1]	-	0.16		0.29		340	150		
01002	ARSENIC, TOTAL (UG/L AS AS)	-	0.82		0.76					
01005	BARIUM, DISSOLVED (UG/L AS BA)	-	34.8		22.4					
01007	BARIUM, TOTAL (UG/L AS BA)	-	49.3		22.2					
01010	BERYLLIUM, DISSOLVED (UG/L AS BE)	-	0.05	QQ	0.01	U				
01012	BERYLLIUM, TOTAL (UG/L AS BE)	-	0.16		0.02	U				
01025	CADMIUM, DISSOLVED (UG/L AS CD)[1,9]	-	0.02	QQ	0.01	U	3.9	1.1		
01027	CADMIUM, TOTAL (UG/L AS CD)	-	0.08	QQ	0.03	QQ				
01030	CHROMIUM, DISSOLVED (UG/L AS CR)[1,9]	-	0.27	QQ	0.66		570	74		
01034	CHROMIUM, TOTAL (UG/L AS CR)	-	3.54		0.16	QQ				
01040	COPPER, DISSOLVED (UG/L AS CU)[1,9]	-	0.69		0.76		13	9	1300	
01042	COPPER, TOTAL (UG/L AS CU)	-	5.78		1.13					
01045	IRON, TOTAL (UG/L AS FE)	-	5150		602					
01046	IRON, DISSOLVED (UG/L AS FE)	-	41.4	QQ	37.1	QQ				
01049	LEAD, DISSOLVED (UG/L AS PB)[1,9]	-	0.06	QQ	0.03	QQ	120	14	15	
01051	LEAD, TOTAL (UG/L AS PB)	-	2.37		0.14					
01055	MANGANESE, TOTAL (UG/L AS MN)	-	301		110					
01056	MANGANESE, DISSOLVED (UG/L AS MN)	-	149		110					
01057	THALLIUM, DISSOLVED (UG/L AS TL)	-	0.04	QQ	0.01	QQ				
01059	THALLIUM, TOTAL (UG/L AS TL)	-	0.11		0.004	U				
01065	NICKEL, DISSOLVED (UG/L AS NI)[1,9]	-	0.52		0.48		180	20	610	4600
01067	NICKEL, TOTAL (UG/L AS NI)	-	3.33		0.69					
01075	SILVER, DISSOLVED (UG/L AS AG)[1,9]	-	0.03	U	0.003	U	3.4			
01077	SILVER, TOTAL (UG/L AS AG)	-	0.03	QQ	0.03	U				
01090	ZINC, DISSOLVED (UG/L AS ZN)[1,9]	-	2.73		1.22		120	120	7,400	26,000
01092	ZINC, TOTAL (UG/L AS ZN)	-	12.26		1.54					
01095	ANTIMONY, DISSOLVED (UG/L AS SB)	-	0.08	QQ	0.03	QQ				
01097	ANTIMONY, TOTAL (UG/L AS SB)	-	0.04	QQ	0.04	QQ				
01105	ALUMINUM, TOTAL (UG/L AS AL)	-	2500		107					
01106	ALUMINUM, DISSOLVED (UG/L AS AL)	-	1.78		5.14					
01145	SELENIUM, DISSOLVED (UG/L AS SE)[1]	-	0.2	U	0.18	QQ	20	5	170	11000
01147	SELENIUM, TOTAL (UG/L AS SE)	-	0.4	QQ	0.33	QQ				
50091	MERCURY-TL,FILTERED WATER,ULTRATRACE METHOD NG/L[1,6,7]	-	1.3	U	1.3	U	1.4	0.77		
50092	MERCURY-TL,UNFILTERED WATER,ULTRATRACE METHOD NG/L	-	7.7		1.4	QQ	1.4	0.77		

NOTES:

** = To maintain acceptable taste, odor or aesthetic quality of drinking water.

1 = All metals shall be measured as dissolved. All aquatic life criteria for metals apply to the biologically available form of the metal. Metals measured as dissolved shall be considered to be biologically available, or, because local receiving water characteristics may otherwise affect the biological availability of the metal, the biologically available equivalent measurement of the metal can be further defined by determining a Water Effect Ratio (WER) and multiplying the numerical value shown in 9 VAC 25-260-140 B by the WER. Refer to 9 VAC 25-260-140 F.

6 = Chronic aquatic life values have been calculated to protect wildlife from harmful effects through ingestion of contaminated tissue. However, the criteria will also protect aquatic life from toxic effects.

7 = Chronic aquatic life criteria applies to methyl mercury. This criteria will protect the marketability of natural resources, e.g.,fish and shellfish.

9 = Freshwater aquatic life criteria for these metals are expressed as a function of total hardness as CaCO3 (mg/l), and as a function of the pollutant's water effect ratio (WER) as defined in 9 VAC 25-260-140 F. Values displayed above in the table are examples and correspond to a total hardness of 100 mg/l and a water effect ratio of 1.0.

QQ = Analyte detected above the MDL but below the method quantification limit.

U = Material analyzed for, but not detected. Value stored is the limit of detection for the process in use.

3.3. *Virginia DEQ Permits and Other Activities in NF Catoctin Creek*

- There are five discharge permits for single-family homes (SFH) in the watershed, shown in Table 3-5.

Table 3-5. VDEQ SFH 1000-GPD Permits

Permit Number	Facility Name	Receiving Stream
VAG406086	Smith Steven D Residence	North Fork Catoctin Creek
VAG406103	Biraben Roger Residence	North Fork Catoctin Creek UT
VAG406175	Zurschmeide Steve Residence	Catoctin Creek - UT
VAG406477	Common Ground	North Fork Catoctin Creek, UT
VAG406539	Price David Residence	North Fork Catoctin Creek

- There are no VPDES permits in the watershed.
- There are no Industrial Stormwater General Permits in the watershed.
- Eight dams are included in the Loudoun County inventory within NF Catoctin Creek watershed, as shown in Table 3-6.

Table 3-6. Loudoun County Dam Inventory within NF Catoctin Creek watershed

ID	Name of Dam	Dam Owner	Classification Description	Length of Impoundment (ft)	Year Completed
10712	Godfrey Dam	M H F LLC	Significant	842	1956
10719	J.T. Hirst Dam	Town of Purcellville	Significant	600	1962
00297	Upper Godfrey Dam	M H F LLC	Significant	519	1990
00300	15164 Berlin Pike Dam	Faith & Family Foundation Inc.	Low	1,754	1990
10775	Shanondale Road Dam	Williams, Michael & Gina Schaecher	Significant	575	
10776	Ashbury Church Road Dam	Baker, Daniel L	Significant	1,376	
10777	Koerner Lane Dam	Michie, Thomas H & Jean Ann R/S	Significant	561	
10731	Upper Purcellville Dam	Town of Purcellville	Significant	1,165	1940

- Biosolids application permits

There are no biosolids permits currently active in the NF Catoctin Creek watershed. Although there may have been an active permit in the past, there have been no current or recent land applications. Poultry litter is being applied, but does not require a permit.

- Water withdrawal summary, Figure 3-17 – Town of Purcellville and Moutoux Orchard, 2000-2014

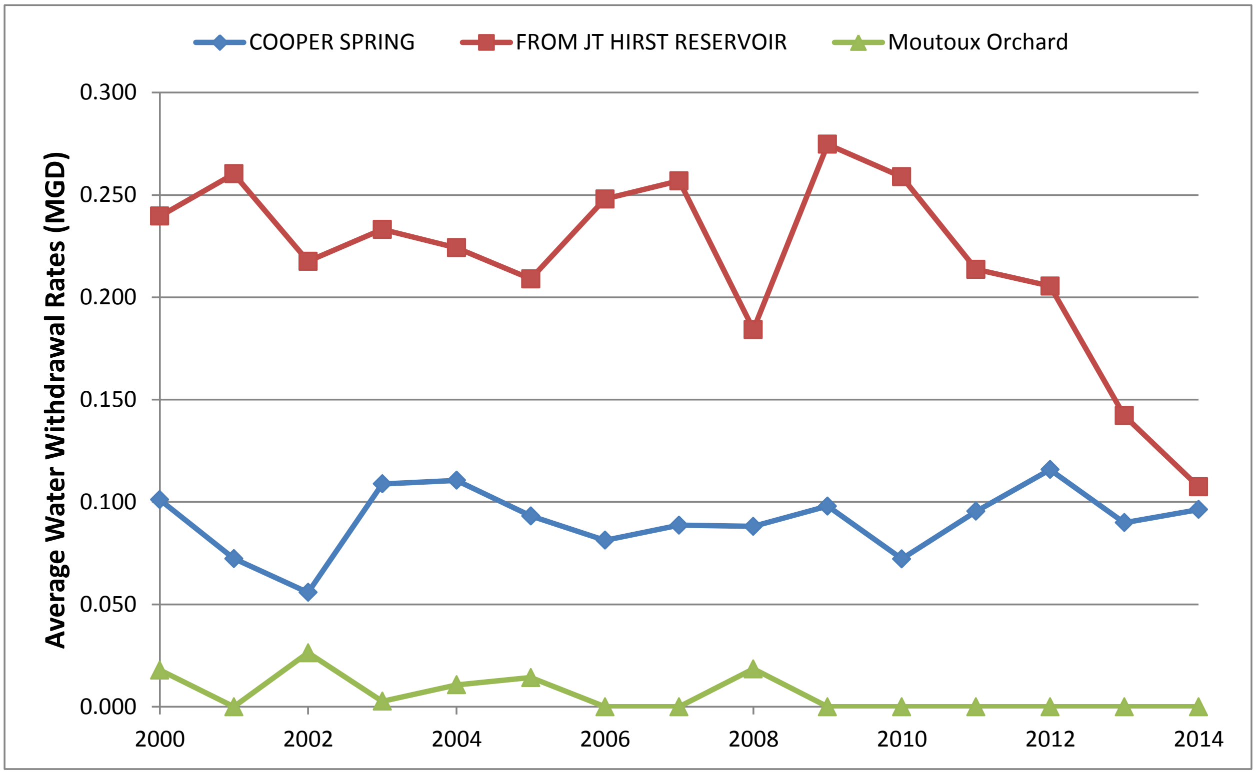

Figure 3-17. Annual Water Withdrawals by the Town of Purcellville and Moutoux Orchard

- History of Godfrey Dam:

The Godfrey Dam was originally built in 1956. Although the DCR dam inventory shows the dam to be operational on 06/08/10, a note was attached stating that the dam had been breached as of 05/26/04. Loudoun County's online Aerial Archive of Godfrey Pond is available at: http://logis.loudoun.gov/archive/default.htm?app=aa&x=11708274.017250199&y=7116856.944566513. Images from 2002 and 2005 show the drained pond, with a full pool shown in the 2006 image.

- Town of Hillsboro Water Supply Plan

The Town of Hillsboro has a small water system serving approximately 40 customers (http://www.virginiaplaces.org/nova/watersourcesnova.html). The Hill Tom Spring, and a well, used by the town of Hillsboro as water sources are inadequate, both from a quality and quantity standpoint. The Town has been under a Virginia Department of Health (VDH)-imposed consent order and boil water notice since 2005, as the spring is under the influence of surface water. In March of 2012, Hillsboro submitted to the VDH Office of Drinking Water (ODW) a Grant Application for the Financial and Construction Assistance Programs to construct a new well, connect it to the existing system, and provide additional storage and infrastructure improvements to the system. In November 2012, VDH approved a total funding package of $1,200,000 for the project. It consists of a $720,000 Drinking Water State Revolving Fund (DWSRF) loan at 2.5% interest for a term of 30 years and $480,000 in grant funding from the Water Supply Assistance Grant Fund. Construction was projected to begin by late fall 2013 (VDEQ, 2015). Although this is a small community, it nevertheless will be another source of future demand on water resources in the NF Catoctin Creek watershed.

3.4. Town of Purcellville Water Supply

The Town of Purcellville obtains its water from a combination of surface water and ground water. The surface water source is the J.T. Hirst Reservoir in the NF Catoctin Creek watershed, built about 1955, which has an operational capacity of 300,000 gallons per day (gpd). The storage capacity of the reservoir is about 29 million gallons. The reservoir is filled by three primary water springs: Harris Spring, Potts Spring, and Cooper Spring. Cooper Spring is piped (gravity line) to a 12-inch pipe just below the reservoir which carries water to the water treatment plant for filtration. The Harris and Potts springs flow directly into the J.T. Hirst Reservoir. Forbes/Cornwell Well System, Main Street Village Well System, Mountain View Well System and Hirst Farm Well System are the ground water sources and collectively have a capacity of 753,000 gpd. The total production capacity is 1,053,000 gpd including the reservoir. The current average use is about 563,000 gpd. The Town owns 1,272 acres around the reservoir and three springs, including much of the watershed for the reservoir (Town of Purcellville, Virginia web site).

3.5. DEQ Pollution Response Preparedness (PReP) Reports

Table 3-7. Record of PReP Incidents

Incident Date	Site Name	Incident Type	Original Call Incident Description
07/13/99	Route 287	Petroleum	Vehicle Accident - hydraulic fluid spill
05/02/01	Hillsboro VDOT	Petroleum	Discovered at night - bull dozer set on fire, released hydraulic fluid to land only, VDOT and State Police investigating VDOT clean up area. No further action required.
05/03/06	Hawkins	Water	Failing multi-flow system used for church/antique shop/house & possibly another connection house/convenience store.
06/29/07	Charles Planck	Fish Kill	Fish kill in private pond. 12-15 dead fish.
10/26/12	Poultry Liter Storage	Agriculture	Stored poultry manure
05/17/13	Poultry litter - Wheatland area	Agriculture	Toxic odor from spread poultry litter
03/04/14	Poultry Litter Storage	Agriculture	Uncovered poultry litter storage
06/27/14	Propane Release	--	Bulldozer struck 500-gal underground propane tank, estimated 400-gal released.

3.6. Virginia DEQ – Other Relevant Monitoring or Reports

- Relative Bed Stability (RBS) Analysis: A Log Relative Bank Stability (LRBS) test is a type of siltation index. An LRBS score of negative one (-1) indicates that sediments ten times larger than the median are moving at bankfull flow, with a medium probability of impairment from sediment. LRBS scores < -1 are considered sub-optimal, while scores > -0.5 are considered optimal.

Table 3-8. RBS Analysis Results

StationID	Date	Slope	% Bedrock	% Sand + Fines	Embeddedness (%)	LRBS*
1ANOC000.42	11/12/14	0.22	9.5%	53.3%	76.2%	-0.520
1ANOC004.38	11/14/14	0.18	5.7%	19.0%	54.5%	0.586
1ANOC009.37	11/12/14	1.06	3.8%	11.4%	44.2%	0.247

* LRBS > -0.5 indicates a normal sediment load;
LRBS < -1.0 indicates excessive sediment load.

3.7. 305(b)/303(d) Integrated Report – Monitored Exceedances.

- In the four 305(b)/303(d) biennial integrated reports for 2008, 2010, 2012, and 2014 (VDEQ, 2008, 2010, 2012, and 2014), station 1ANOC000.42 on NF Catoctin Creek has been listed with a biological impairment, and in 2014 a station on the upper NF Catoctin (1ANOC009.37) was added with a benthic impairment. The following table summarizes the monitored exceedances over these periods for monitored water quality parameters.

Table 3-9. Summary of Monitored Water Quality Standard Exceedances on NF Catoctin Creek

ID305B	STATION ID	STATION TYPE	CONVENTIONAL WATER COLUMN									BACTERIA DATA DATA			WATER COLUMN				SEDIMENT				FISH TISSUE				Bio Mon
			Temperature			Dissolved Oxygen			pH			E. Coli			Metals		Toxics		Metals		Toxics		Metals		Toxics		
2008			Violations	# Samples	Status	Violations	# Samples	Status	Violations	# Samples	Status	Violations	# Samples	Status	Violations	Status	Violations	Status	Violations	Status	Violations	Status	Violations	Status	Violations	Status	Status
VAN-A02R_NOC01A00	1aNOC-0.42-LWC	CMON	0	0		0	0		0	0		6	6	IN/O	0		0		0		0		0		0		
VAN-A02R_NOC01A00	1ANOC000.42	A,B,CR	0	4	S	0	4	S	0	4	S	0	0	0	0		0	S	0	S	0	S	0		0		IM
VAN-A02R_NOC02A02	1ANOC007.28	A,CR	0	3	S	0	3	S	0	3	S	3	3	IM	0		0	S	0		0		0		0		
VAN-A02R_NOC03A02	1ANOC009.37	A	0	11	S	0	9	S	0	11	S	4	10	IM	0		0	S	0		0		0		0		
VAN-A02R_NOC01A00	1aNOC-1-LWC	CMON	0	0		0	0		0	0		0	0	0	0		0		0		0		0		0		MP
VAN-A02R_NOC02A02	1aNOC-4.38-LWC	CMON	0	0		0	0		0	0		2	5	IN/O	0		0		0		0		0		0		
VAN-A02R_NOC03A02	1aNOC-9.37-LWC	CMON	0	0		0	0		0	0		2	5	IN/O	0		0		0		0		0		0		
2010																											
VAN-A02R_NOC01A00	1ANOC-0.42-LWC	CMON	0	0		0	0		0	0		65	89	IN/O	0		0		0		0		0		0		
VAN-A02R_NOC01A00	1ANOC000.42	A,B,TM	0	17	S	0	17	S	0	17	S	9	12	IM	0		0	S	0		0		0		0		IM
VAN-A02R_NOC02A02	1ANOC007.28	A,CR	0	7	S	0	7	S	0	7	S	6	7	IM	0		0	S	0		0		0		0		
VAN-A02R_NOC03A02	1ANOC009.37	A	0	11	S	0	9	S	0	11	S	4	10	IM	0		0	S	0		0		0		0		
VAN-A02R_NOC01A00	1ANOC-1-LWC	CMON	0	0		0	0		0	0		0	0	0	0		0		0		0		0		0		MP
VAN-A02R_NOC02A02	1ANOC-4.38-LWC	CMON	0	0		0	0		0	0		30	66	IN/O	0		0		0		0		0		0		
VAN-A02R_NOC03A02	1ANOC-9.37-LWC	CMON	0	0		0	0		0	0		37	80	IN/O	0		0		0		0		0		0		
2012																											
VAN-A02R_NOC01A00	1ANOC-0.42-LWC	CMON	0	0		0	0		0	0		65	89	IN/O	0		0		0		0		0		0		
VAN-A02R_NOC01A00	1ANOC000.42	A,B,TM	0	21	S	0	21	S	0	21	S	9	12	IM	0		0	S	0		0		0		0		IM
VAN-A02R_NOC02A02	1ANOC004.38	A,SS	0	13	S	0	13	S	0	13	S	3	12	IM	0		0		0		0		0		0		
VAN-A02R_NOC02A02	1ANOC007.28	A,CR	0	7	S	0	7	S	0	7	S	6	7	IM	0		0	S	0		0		0		0		
VAN-A02R_NOC03A02	1ANOC009.37	A,B	0	6	S	0	5	S	0	6	S	1	4	IN	0		0	S	0		0		0		0		FS
VAN-A02R_NOC02A02	1ANOC-4.38-LWC	CMON	0	0		0	0		0	0		30	66	IN/O	0		0		0		0		0		0		
VAN-A02R_NOC03A02	1ANOC-9.37-LWC	CMON	0	0		0	0		0	0		37	80	IN/O	0		0		0		0		0		0		
2014																											
VAN-A02R_NOC01A00	1ANOC-0.42-LWC	CMON										41	55	IN/O													
VAN-A02R_NOC01A00	1ANOC000.42	A,B,TM	0	30	S	1	30	S	0	30	S	16	22	IM			0	S									IM
VAN-A02R_NOC02A02	1ANOC004.38	A,B,TM,SS	0	26	S	0	26	S	0	26	S	7	22	IM			0	S									FS
VAN-A02R_NOC02A02	1ANOC007.28	A,CR	0	4	S	0	4	S	0	4	S	3	4	IM			0	S									
VAN-A02R_NOC03A02	1ANOC009.37	A,B	0	2	S	0	2	S	0	2	S																IM
VAN-A02R_NOC02A02	1ANOC-4.38-LWC	CMON										17	37	IN/O													
VAN-A02R_NOC03A02	1ANOC-9.37-LWC	CMON										20	41	IN/O													

Ambient Monitoring Status Codes

Status Code	Status Code Description
IM	Impaired
IN	Insufficient Data
IN/O	Insufficient Data with Observed Effects
O	Observed Effects
S	Supporting

Biological Monitoring Status Codes

Status Code	Status Code Description
FS	Fully Supporting VSCI or CPMI
IM	Impaired for VSCI or CPMI
MP	Citizen Monitoring - Medium Probability for Adverse Conditions (Insufficient Information but having Observed Effects)

3.8. Stream Flow Data in NF Catoctin Creek

During the period of record from 07/01/01 through 03/30/15, a period of 5,002 days, 121 days have recorded a daily average flow of less than 0.1 cfs, and 394 days have recorded a daily average flow less than 1.0 cfs. While the average daily flow is 24.52 cfs, the median daily flow is only 12.0 cfs. Figure 3-18 illustrates short-term patterns during 2012, when periodic samples were taken at two additional stream sites by DEQ monitors. Figure 3-19 displays the average daily flow and monthly precipitation, averaged by month, illustrating a pattern of very low flows between July and October in NF Catoctin Creek over the 14 years of flow records at 01638420.

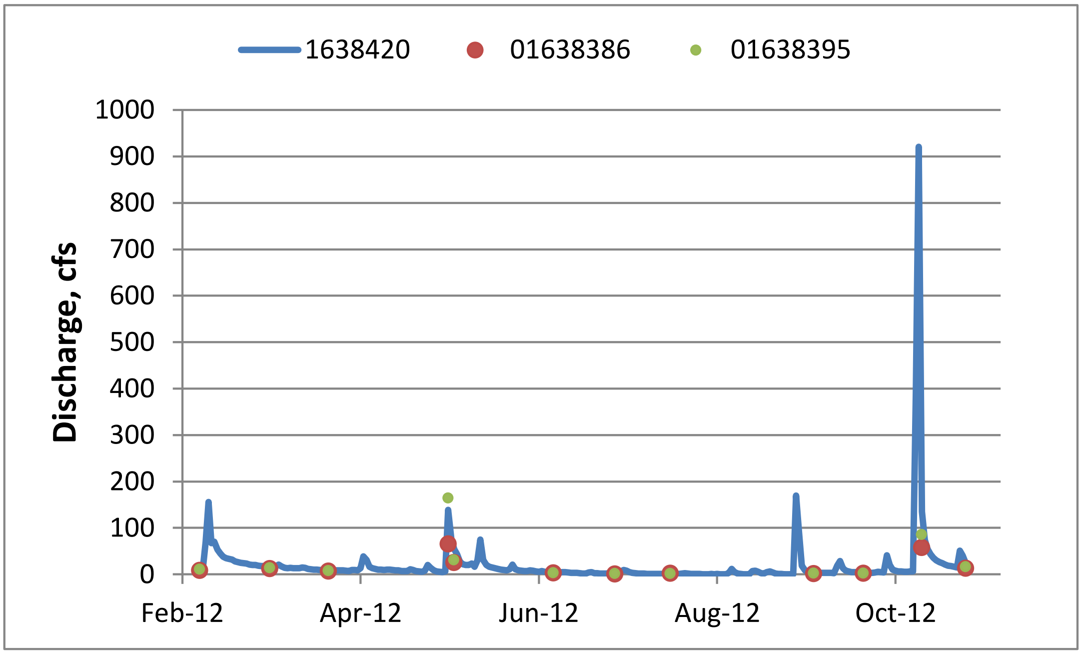

Figure 3-18. Short-term DEQ monthly flow (01638386, 01638395) and daily USGS flow (01638420)

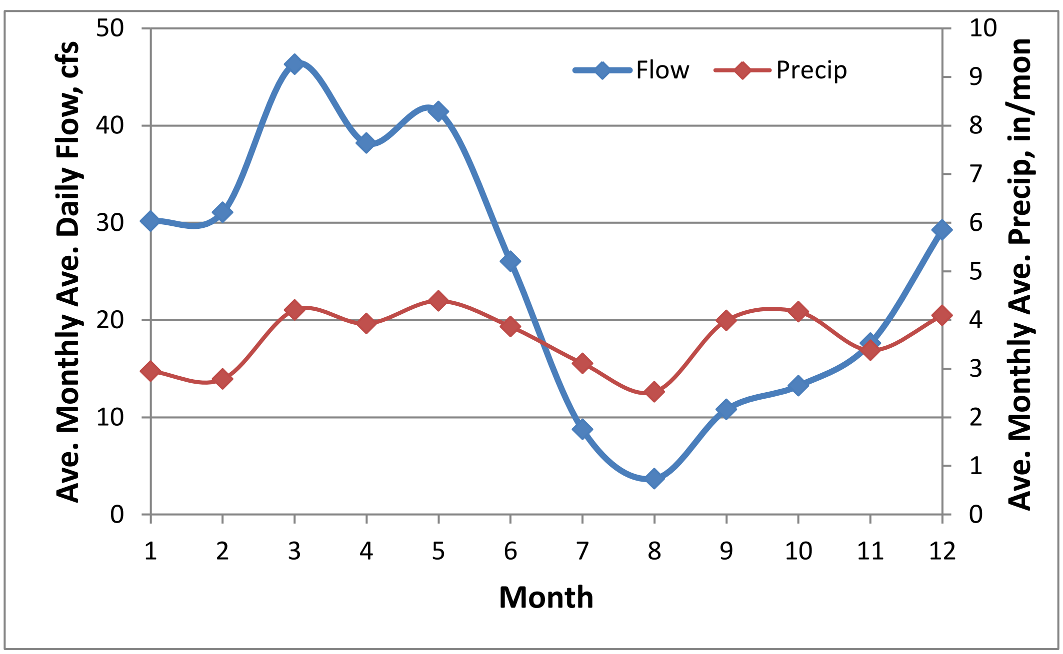

Figure 3-19. USGS Average Monthly Average Daily Flow for USGS01638420, 2001-2014

Figure 3-20 shows the minimum August flow for each year of the historic record. The August low flow (ALF) metric, shown by the dashed red line, represents the median of those minima. Since late summer flows are expected to impact aquatic ecology, this flow statistic is used to get a sense of how often an aquatic organism may be exposed to dangerously low flows over its lifetime. These ecological flow statistics, one being the August Low Flow, stem from The Nature Conservancy's Indicators of Hydrologic Alteration (IHA) software. TetraTech did a study in 2011 for VDEQ to compile a huge amount of biological monitoring data with a long list of flow statistics, producing ~10,000 plots and regressions, and August Low Flow was one of the metrics that stood out as indicative of ecological change.

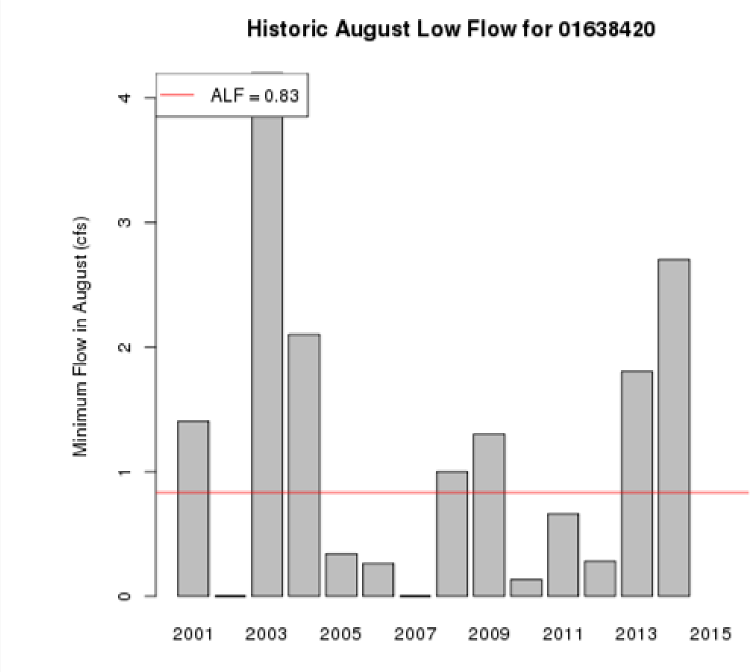

Figure 3-20. August Low Flow (ALF) Metric for USGS Station 01638420, NF Catoctin Creek at Rt. 681

The slide in Figure 3-21 is from a 2007 presentation by CH2M Hill to the Loudoun County Water Resources Technical Advisory and Loudoun Watershed Management Stakeholder Steering Committees. It illustrates the relatively greater influence of drought conditions on residual groundwater in the NF Catoctin Creek watershed (the lighter green and yellow colors) than in surrounding watersheds in the County.

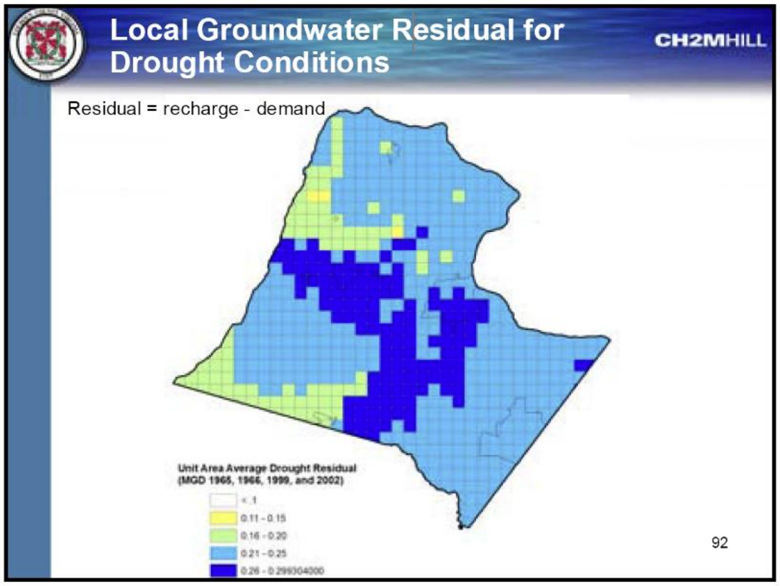

Figure 3-21. Loudoun County Groundwater Residual for Drought Conditions

3.9. VAHWQP Household Drinking Water Analyses

- The Virginia Household Water Quality Program (VAHWQP) conducted Drinking Water clinics in Loudoun County in June 2010 and again in October 2013 (Benham et al., 2013), where homeowners brought in well or spring water samples and/or tap water samples for water quality testing and analysis (Table 3-10). Some samples were from well water and some from tap water. While the samples may not be representative of the groundwater quality in the area, they do provide some information on general levels of physical and chemical constituents that may arise from groundwater.
- This program uses the EPA primary and secondary standards of the Safe Drinking Water Act, which are enforced for public systems and serve as guidelines for private water supplies.

Table 3-10. Virginia Household Water Quality Program, County Drinking Water Clinic Results

2010 Loudoun County
VAHWQP Drinking Water Clinic Results
N = 96 samples

Test	EPA Standard	Average	Maximum Value	% Exceeding Standard
Iron (mg/L)	0.3	0.125	2.167	10.4
Manganese (mg/L)	0.05	0.051	0.945	25.0
Hardness (mg/L)	180	94.4	336.1	9.4
Sulfate (mg/L)	250	15.4	53.6	0
Chloride (mg/L)	250	16	155	0
Fluoride (mg/L)	2.0/4.0	0.24	2.83	2.1
Total Dissolved Solids	500	216	697	1.0
pH	6.5 to 8.5	7.13	9.46	14.6 (<6.5) 1.0 (>8.5)
Copper (mg/L)	1.0/1.3	0.040	1.499	1.0
Sodium (mg/L)	20	22.15	194.32	27.1
Nitrate - N (mg/L)	10	0.882	8.145	0
Total Coliform Bacteria	ABSENT	--	--	44.8
E. coli Bacteria	ABSENT	--	--	4.2

2013 Loudoun County
VAHWQP Drinking Water Clinic Results
N = 45 samples

Test	EPA Standard*	Average	Maximum Value	% Exceeding Standard
Iron (mg/L)	0.3	0.1	0.843	11.1
Manganese (mg/L)	0.05	0.019	0.415	6.7
Hardness (mg/L)	180	82.7	191.8	4.4
Sulfate (mg/L)	250	14.5	33.	0.0
Fluoride (mg/L)	2.0/4.0	0.21	1.95	0.0
Total Dissolved Solids	500	198.	538.	2.2
pH	Min 6.5	7.2	5.8 (min)	13.3 (< 6.5)
	Max 8.5		9.2 (max)	4.4 (> 8.5)
Sodium (mg/L)	20	21.04	91.31	24.4
Nitrate - N (mg/L)	10	1.48	8.314	0.0
Copper-First Draw (mg/L)	1.0/1.3	0.572	6.21	11.1
Copper-Flushed (mg/L)	1.0/1.3	0.053	0.499	0.0
Lead-First Draw (mg/L)	0.015	0.012	0.221	15.6
Lead-Flushed (mg/L)	0.015	0.	0.003	0.0
Arsenic-First Draw (mg/L)	0.010	0.0011	0.0011	0.0
Arsenic-Flushed (mg/L)	0.010	0.001	0.0011	0.0
Total Coliform Bacteria	ABSENT	--	--	46.7
E. Coli Bacteria	ABSENT	--	--	15.6

*EPA primary and secondary standards of the Safe Drinking Water Act are used as guidelines for private water supplies

3.10. Loudoun Watershed Watch (LWW) Bacteria Data (2005-2009)

- Bi-monthly bacteria (*Escherichia coli*) monitoring was performed at three sites in the North Fork Catoctin Creek by LWW volunteers between 2005 and 2009. The stations are named 1ANOC-0.42-LWW, 1ANOC-4.38-LWW, and 1ANOC-9.13-LWW and roughly correspond to the locations of three DEQ monitoring sites.

Table 3-11. Summary of LWW Bacteria Monitoring

Station	No. of Samples	Date of First Sample	Date of Last Sample
1ANOC-0.42-LWW	140	6/15/2005	8/5/2009
1ANOC-4.38-LWW	111	7/20/2005	3/18/2009
1ANOC-9.13-LWW	118	7/9/2005	3/18/2009

- A plot of the *E. coli* monitoring data for all LWW monitoring stations on NF Catoctin Creek are shown in Figure 3-22.

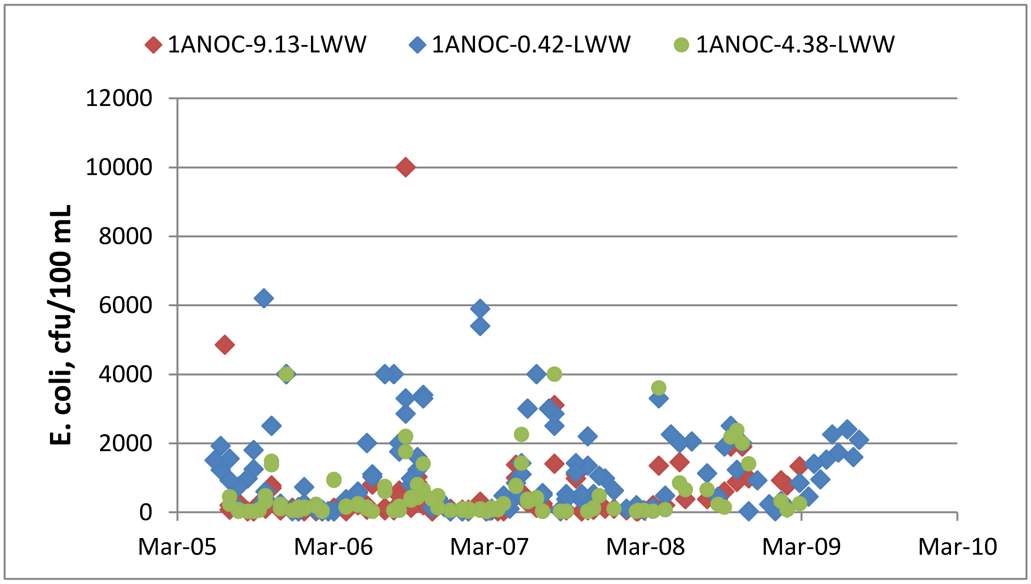

Figure 3-22. Time-series of LWW *E.coli* monitoring

3.11. NRCS Fish IBI and Stream Visual Assessment Protocol (SVAP) Data (2000-2003)

Over 15,000 acres of forested riparian buffers were established from 2000 through 2003 through Virginia's Conservation Reserve Enhancement Program (CREP) program. This USDA study was conducted on various Northern Virginia streams, including one site on the NF Catoctin Creek above Route 287 near Wheatland and DEQ station 1ANOC004.38 (USDA-NRCS, 2005). The goal of the study was to quantify the impact of the buffers on fish assemblages using the fish index of biological integrity (IBI) and on riparian habitat using the NRCS Stream Visual Assessment Protocol (SVAP). Notes on this site included the following evaluation "Restoration has caused a positive response in both herbaceous and woody cover. Upstream bridge construction impacted SVAP and IBI scores in 2002; however, the site has been trending upward since buffer establishment in 2000." The upward trending results are also shown below in Table 3-12 and Table 3-13.

Table 3-12. NF Catoctin Creek IBI Metrics and Scores, 2000-2003

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	17	3	20	5	20	5	19	3
# darter species	3	5	3	5	3	5	3	5
# minnow species	11	3	13	3	13	3	9	3
% dominant species	0.259	3	0.209	3	0.141	5	0.160	5
# intolerant species	0	1	0	1	1	1	2	3
% tolerant individuals	0.557	1	0.530	1	0.454	3	0.514	1
% omnivores	0.401	1	0.339	1	0.271	1	0.204	3
% benthic invertivores	0.279	5	0.216	3	0.159	3	0.333	5
% specialist carnivores	0.054	1	0.042	1	0.058	1	0.038	1
% simple lithophils	0.156	1	0.145	1	0.128	1	0.149	1
# late maturing species	3	3	3	3	2	1	4	5
% anomalies	0.029	3	0.040	3	0.036	3	0.000	5
IBI		**30**		**30**		**32**		**40**

Table 3-13. NF Catoctin Creek SVAP Elements and Ratings, 2000-2003

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition	8.7	8.4	8.7	9.0
Hydrologic alteration	7.7	8.3	8.7	8.3
Riparian width	8.0	8.7	8.0	8.0
Bank stability	7.7	8.2	8.0	8.0
Canopy cover	9.7	8.2	9.0	8.7
Water appearance	6.3	8.4	4.7	7.7
Nutrient enrichment	7.0	7.8	6.3	7.7
Manure presence				
Fish barriers	9.3	10.0	10.0	10.0
Fish cover	7.7	8.7	8.7	8.0
Pools	7.0	8.3	7.0	6.7
Riffle quality	5.3	7.8	5.7	7.7
Invertebrate habitat	8.0	7.7	7.7	8.3
Invertebrates observed	7.7	10.8	7.7	11.7
SVAP	**7.7**	**8.6**	**7.7**	**8.4**

3.12. DCR BMP Installation Data for VAHU6 PL02 (1998-2014)

Virginia Agricultural Cost-share data were provided by Virginia DCR for the PL02 6th Order Hydrologic Unit and relevant data were extracted for the North Fork Catoctin Creek watershed. Table 3-14 provides a summary of best management practices (BMPs) installed in the upper and lower portions of the NF Catoctin Creek watershed. A summary of the BMP types and extents by year are shown in Table 3-14. Implementation of the Catoctin Creek Bacteria TMDL Implementation Plan occurred during 2005-2009, as highlighted in Table 3-15. In the final year of implementation (2009) new statewide TMDL-specific cost-share practices were introduced (fencing and water systems at 85% cost-share and a reduced setback requirement at 50% cost-share), which spurred an increase in farmer participation.

Table 3-14. Summary of Installed BMPs 1998-2014 by Sub-watershed

BMP Code	BMP Name	Units	Lower NF Catoctin Cr.	Upper NF Catoctin Cr.	Total
CCI-SE-1	Stream Exclusion - Maintenance Practice	Lin. Feet		1700	1700
CP-22	Riparian Buffer Rent	Acres		3.1	3.1
CRFR-3	CREP Riparian Forest Buffer Planting	Acres		3.1	3.1
FR-1	Aforestation of erodible crop and pastureland	Acres		12	12
FR-3	Woodland buffer filter area	Acres		5	5
LE-1T	Livestock Exclusion with Riparian Buffers for TMDL Imp.	Lin. Feet		3982	3982
RB-1	Septic Tank Pumpout	Count	2	1	3
RB-3	Septic Tank System Repair	Count	2	1	3
RB-4	Septic Tank System Replacement	Count	3	1	4
RB-5	Installation of Alternative Waste Treatment System	Count		2	2
SL-1	Permanent Vegetative Cover on Cropland	Acres	174.6	703.3	877.9
SL-11B	Farm Road or Heavy animal Travel lane Stabilization	Acres	300		300
SL-6	Stream Exclusion With Grazing Land Management	Lin. Feet	12411.5	11482	23893.5
SL-8B	Small Grain cover crop for Nutrient Management	Acres	355	288	643
SL-8H	Harvestable Cover Crop	Acres	49.8	305.2	355
WL-3	Fescue Conversion/Wildlife Option	Acres	25.9		25.9
WP-2	Streambank protection (fencing)	Lin. Feet	4942	3500	8442
WP-2T	Stream Protection - TMDL	Lin. Feet		1152	1152

Table 3-15. Summary of BMP Types and Extents Installed by Year, 1998-2014

BMP Code	BMP Name	Units	Extent Installed by Year																	Total
			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
CCI-SE-1	Stream Exclusion - Maintenance Practice	Lin. Feet																1700		1700
CP-22	Riparian Buffer Rent	Acres					3.1													3.1
CRFR-3	CREP Riparian Forest Buffer Planting	Acres					3.1													3.1
FR-1	Aforestation of erodible crop and pastureland	Acres		3	4			5												12
FR-3	Woodland buffer filter area	Acres		1	4															5
LE-1T	Livestock Exclusion with Riparian Buffers for TMDL Imp.	Lin. Feet													3982					3982
RB-1	Septic Tank Pumpout	Count											1	2						3
RB-3	Septic Tank System Repair	Count									1	1	1							3
RB-4	Septic Tank System Replacement	Count												1	3					4
RB-5	Installation of Alternative Waste Treatment System	Count												1	1					2
SL-1	Permanent Vegetative Cover on Cropland	Acres	27	110.4	152.7	29	83.1		8	26.5	164	139.1		10	75.2	23.9	29			877.9
SL-11B	Farm Road or Heavy animal Travel lane Stabilization	Acres	300																	300
SL-6	Stream Exclusion With Grazing Land Management	Lin. Feet	52.5		12,289	790	2,264					280	185	643			2,812	378	4,200	23,894
SL-8B	Small Grain cover crop for Nutrient Management	Acres			123.4	50	21.8	60		65	97	17.1	48.7				80	80		643
SL-8H	Harvestable Cover Crop	Acres											79.8	75.2			141	59		355
WL-3	Fescue Conversion/Wildlife Option	Acres		25.9																25.9
WP-2	Streambank protection (fencing)	Lin. Feet	4,242	0	1,890			410	700								1,200			8,442
WP-2T	Stream Protection - TMDL	Lin. Feet									512	270	370							1,152

- Catoctin Creek (bacteria) TMDL Implementation period.

3.13. MWCOG Rapid Stream Assessment Technique (RSAT) Data (2005-2006)

Under Phase II of a proposed multi-phased study, Catoctin Creek was one of six watersheds surveyed to systematically evaluate existing physical, chemical and biological stream quality conditions. Using the Metropolitan Washington Council of Government's (MWCOG's) Rapid Stream Assessment Technique (RSAT), 16 strategically located and representative mainstem and tributary sites (one of which was located on the upper NF Catoctin Creek near Hillsboro and DEQ station 1ANOC009.38) were surveyed between October 2005 and April 2006 (MWCOG, 2006). The report presents the findings of the RSAT survey, and provides valuable baseline data for assessing general stream conditions in the watersheds.

In addition, COG staff analyzed existing riparian buffer conditions under 35, 50, 100, and 200 foot width scenarios (on both sides of the stream) for the Catoctin Creek watershed. Using the Loudoun County stream geodata file and year 2005 Spot 5 satellite imagery within the ArcGIS platform, riparian buffer conditions were additionally classified into two generic forest and non-forest categories.

Major summary findings for each of the six RSAT categories (i.e., Streambank Stability, Channel Scouring/Sediment Deposition, Physical Aquatic Habitat, Water Quality, Riparian Habitat Conditions, and Biological Indicators (Benthic Macroinvertebrates)) and the riparian buffer condition analyses are presented in the following excerpts from the report for the NF Catoctin Creek watershed.

The mean bank stability rating for the North Fork was 74.2 percent, placing it in the good range. As shown in Table 10, streambank erosion survey totals were as follows: 192.2 linear feet of moderate erosion, no moderate/severe erosion and 153.5 linear feet of severe bank erosion. In addition, two recent tree falls were documented within the North Fork mainstem. No erosional log jams were recorded. The bank stability ranged from 45 (i.e., poor) to 93 percent (i.e., excellent), and included 153.5 linear feet of severe channel erosion which amounted to an erosional rate of 248.8 linear feet/mile.

Table 10. Catoctin Creek - Streambank Erosion Conditions

RSAT Stream Segment	Surveyed Stream Length (ft.)	Surveyed Streambank Network[1] Length (ft.)	Bank Erosion Conditions						No. of Recent Tree Falls[2]		No. of Erosional Log Jams	Mean Bank Stability (%)[3]
			Severe		Moderate/Severe		Moderate					
			(LF)	(LF/mi.)	(LF)	(LF/mi.)	(LF)	(LF/mi.)	No.	No./mi.		
Catoctin Creek Mainstems												
Upper - North Fork (Hillsboro Rd.)	1,628.1	3,256.2	153.5	248.8	0.0	0.0	192.2	311.6	2.0	3.2	0.0	74.2

[1] Length to include both the left and right bank (i.e., twice the distance of the surveyed stream length).

[2] Tree fall interpretation: 0-1/mi. = Excellent, 2-3/mi. = Good, 4-5/mi = Fair, ≥6 = Poor.

[3] Bank stability interpretation: >80% = Excellent, 71-80% = Good, 50-70% = Fair, <50% = Poor.

The mean bank heights (Table 11) for the North Fork at Hillsboro Road fell within the expected or reference condition bank height range of 3-4 feet.

Table 11. Summary: Catoctin Creek – Stream Channel Downcutting

RSAT Stream Segment	Drainage Area (mi²)	Surveyed Stream Length	Mean Bank Height R[1] (ft)	Mean Bank Height L[2] (ft)	Mean Bank Height (ft)	Expected Bank Height Range (ft)	Number of Nick Points
Catoctin Creek							
Upper - North Fork (Hillsboro Rd.)	14.6	1,628	2.9	3.0	3.0	3-4	0

[1] Right bank looking downstream.
[2] Left bank looking downstream.

The observed riffle embeddedness level, shown in Table 12, was in the good category.

Table 12. Summary: Catoctin Creek – Channel Scouring/Sediment Deposition Conditions

RSAT Stream Segment	Surveyed Stream Length (ft.)	Percent Riffle Embbeddedness[3]		Large Point Bars				Relative Level of In-Channel Sand Deposits
		Observed Range	Mean	Total Number Observed	No. Unstable	Percent Unstable (%)	No.of Unstable/ Mile	
Catoctin Creek Mainstems								
Upper - North Fork (Hillsboro Rd.)	1,628	30-40	36.7	1	1	100	3.2	Low

[3] Riffle embeddedness rating scale: <25% = Excellent, 25-50% = Good, 51-75% = Fair, >75% = Poor.

RSAT aquatic habitat ratings (Table 13) were excellent for the North Fork at Hillsboro Road. At the site, the riffle substrate composition was good (i.e., 4.0 points). Riffle substrate composition was predominantly larger cobble and rubble with little sand. Mean wetted perimeter width was rated excellent (i.e., >80 percent) for the North Fork at Hillsboro Road (i.e., 91.3 percent).

Table 13. Summary: Catoctin Creek - General Physical Aquatic Habitat Conditions[1]

RSAT Stream Segment	Riffle Characteristics				Pool Characteristics				Fish Barriers		RSAT Physical Habitat Score (pts.)[6]
	No. of Riffles	Mean Riffle Depth (in.)	Mean Riffle Substrate Quality (pts.)[2]	Mean Riffle Embedded-ness(%)[3]	No. of Pools	Mean Max. Depth (in.)	Mean Pool Quality (pts.)[4]	Riffle/ Pool Ratio[5]	Total Number	Per Mile	
Catoctin Creek Mainstems											
Upper - North Fork (Hillsboro Rd.)	9	5.7	4.0	36.7	10	21.6	3.0	0.9	0	0	7

At the North Fork at Hillsboro Road site, the instantaneous orthophosphate concentration was 0.54 mg/l. According to Dunne and Leopold (1978), 'Long-term eutrophication will usually be prevented if total phosphorus and orthophosphate levels are below 0.5 mg/l and 0.05 mg/l, respectively'. North Fork (Hillsboro Road) had the highest TDS (i.e., 150 mg/l), nitrate (i.e., 2.7 mg/l), and mean substrate fouling (i.e., 60 mg/l) levels observed for the three Catoctin Creek mainstem areas. Direct livestock (cattle) access to the stream is believed to be a major negative factor.

At the North Fork at Hillsboro Road site, the highest mainstem mean canopy coverage (Table 14) was 78.0 percent (i.e., good range). Riparian buffer zone vegetation was also primarily hardwood forest and generally greater than 200 feet wide.

Table 14. Summary: Catoctin Creek - Riparian Habitat Conditions

RSAT Stream Segment	Surveyed Stream Length (ft.)	Number of Observations	Mean Canopy Coverage (%)[1]	Riparian Habitat Conditions	
				RSAT Score[2]	Verbal Ranking
Catoctin Creek Mainstems					
Upper - North Fork (Hillsboro Rd.)	1,628.1	5	78.0	6	Excellent

[1] Mean canopy coverage interpretation: ≥ 80% = Excellent, 60-79% = Good, 50-59% = Fair, <50% = Poor.

[2] Point Score Interpretation: 6.0-7.0 = Excellent, 4.0-5.9 = Good, 2.3-3.9 = Fair, 0-1.9 = Poor.

The macroinvertebrate community conditions (Table 15) for NF Catoctin Creek were rated as good. The RSAT voucher total number of taxa was 16 for the NF Catoctin Creek site. Taxa from the pollution intolerant stonefly, mayfly and caddisfly groups (i.e., Ephemeroptera, Plecoptera and Trichoptera - EPT) were present at the North Fork site. The IBI score at NF Catoctin (76.0) was rated as good. In the RSAT voucher sample, the relative abundance of netspinning caddisflies (moderately pollution tolerant) was 'common'. At the North Fork site, a total of only 77 individuals were collected in the 20-jab sample survey in April 2006. Therefore, the index of biotic integrity results for this stream segment should be viewed with caution.

Table 15. Summary: Catoctin Creek - 1m^2 Macroinvertebrate Sample Metrics and Fairfax County SPS IBI Score and Rating[1]

RSAT Stream Segment	Approx. Stream Segment Location	Survey Date	Total Number of Ind.	Taxa Richness[2]	EPT Richness[3]	Percent EPT[4]	Percent Trichoptera w/o Hydropsychidae[5]	Percent Coloeoptera[6]	Family Biotic Index[7]	Percent Dominance[8]	Percent Clingers + Percent Plecoptera[9]	Percent Shredder[10]	Percent Predators[11]	IMBI[12]	SPS Rating
Catoctin Creek															
Upper - North Fork	Hillsboro Road	4/21/2005	77	16.0	5.0	26.0	1.3	2.6	4.3	45.5	0.0	1.3	3.9	76.0	Good

[1] Scores and rating were developed by Fairfax County Stream Protection Strategy.

[2] Taxa richness represents the total number of taxa collected and is interpreted by SPS as follows: >= 21 = Excellent, 13–20 = Good, 9-12 = Fair, 5-8= Poor, <5 = Very Poor.

[3] Counts the distinct taxa considered pollution intolerant within the groups of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). EPT taxa metrics are interpreted as follows: >7 = Excellent, 5-6 = Good, 4 = Fair, 2-3 = Poor, <=1 = Very Poor.

[4] Measures the abundance of generally pollution intolerant Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) relative to other often more tolerant individuals and is interpreted as follows: >16.6 = Excellent, 12.4-16.5% = Good, 8.3-12.3% = Fair, 4.1-8.2% = Poor, >1.9% = Very Poor.

[5] Measures the absence of generally pollution tolerant Hydropsychidae (caddisflies) relative to other more intolerant Caddisflies and is interpreted as follows: >0.79% = Excellent, 0.60-0.78% = Good, 0.40-0.59% = Fair, 0.39-0.20% = Poor, <0.20% = Very Poor.

[6] Measures the abundance of generally pollution intolerant Coleoptera (beetles) relative to other individuals and is interpreted as follows: >1.00% = Excellent, 0.75 – 0.99% = Good, 0.50-.74% = Fair, 0.25 – 0.49% = Poor and < 0.24% = Very Poor.

[7] The Family Biotic index measures the general tolerance/intolerance of the sample to organic nutrients and is interpreted as follows: 0.00-3.50 = Excellent, 3.51-5.50 = Good, 5.51-7.50 = Fair, 7.51-8.50 = Poor, > 8.51 Very Poor.

[8] Measures the percent of the most abundant taxa relative to the total taxa within the sample and represents community balance. It is interpreted as follows: <60% = Excellent, 61-68.5% = Good, 68.6-84.0% = Fair, 84.5-92.0%= Poor, >92.0% = Very Poor.

[9] Measures the percent of individuals whose habitat type is clingers plus percent of sample that are stoneflies but are not clingers and is interpreted as follows: >3.28% = Excellent, 2.46-3.27% = Good, 1.63-2.45% = Fair, 0.84-1.62%= Poor, <0.84% = Very Poor.

[10] Measures the percent of individuals that are shredders relative to all other feeding guild types and is interpreted as follows: >5.42% = Excellent, 4.10-5.41% = Good, 2.70-4.00% = Fair, 1.39-2.69% = Poor, <1.39% = Very Poor.

[11] Measures the percent of individuals that are predators relative to all other feeding guild types and is interpreted as follows: >2.30% = Excellent, 1.52-2.00% = Good, 1.02-1.51% = Fair, 0.50-1.01% = Poor, <0.50% = Very Poor.

[12] SPS IBI score interpretation: 80-100 = Excellent, 60-79 = Good, 40-59= Fair, 20-39 = Poor, 0-19 = Very Poor.

While the overall water quality in the NF Catoctin Creek site was only rated as "fair", as shown in Table 16, bank and channel indicators were rated as "good", and the habitat and biological metrics were all rated as "excellent", leading to an overall RSAT rating of "good".

Table 16. Catoctin Creek Study Summary: RSAT Ratings[1]

RSAT Stream Segment	Approx. Stream Segment Location	Bank Stability	Channel Scouring/ Deposition	Physical Instream Habitat	Water Quality	Riparian Habitat Conditions	Biological Indicators	RSAT Total Score[2]
Catoctin Creek Mainstems								
Upper - North Fork	Hillsboro Road	Good (7)	Good (6)	Excellent (7)	Fair (4)	Excellent (6)	Excellent (7)	**Good (37)**

[1] Actual point values are shown in parentheses.

[2] Total RSAT score interpretation: 42-50 = Excellent, 30-41 = Good, 16-29 = Fair, <16 = Poor.

3.14. Loudoun County WebLogis Data

Loudoun County's online geographic information system, WebLogis, has a number of additional data layers that provided useful background information. The first is a data layer of Potential Pollution Sources. This data layer includes potential pollution sources in the county that have been identified and assigned a unique SITE-ID number. Cemeteries are included as a potential groundwater and soil pollution source. The majority of pollution sources are individual sewage disposal (septic/drain field) systems. Note that all identified pollution sources are not necessarily causing pollution but, rather, can be simply a potential source of pollution. Information for pollution sources comes primarily from the Health Department permitting and inspection process and/or date of discovery from field verification (Loudoun County WebLogis – Pollution Sources Metadata). Figure 3-23 shows the distribution of the potential pollution sources throughout the watershed, while Table 3-16 provides a summary of each type of potential source.

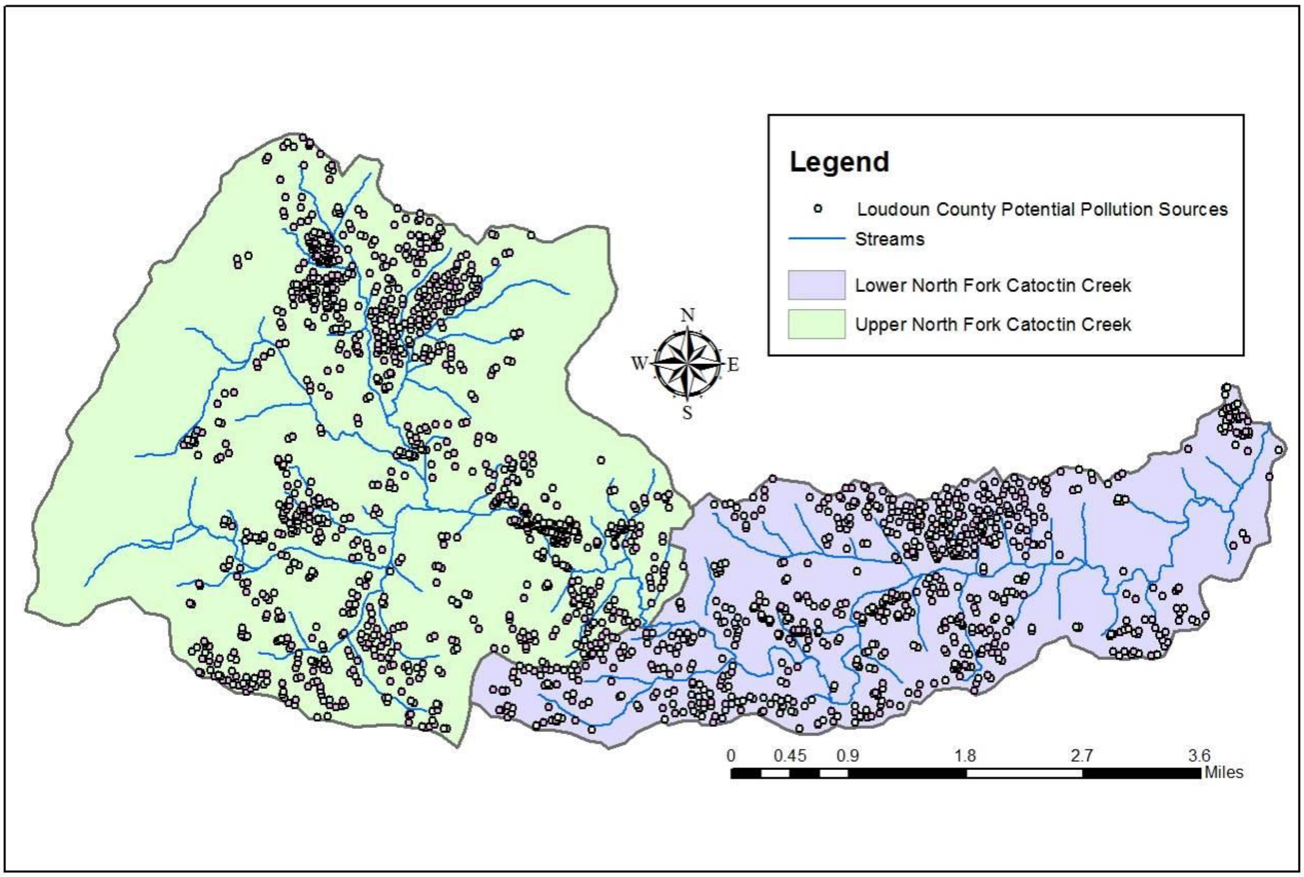

Figure 3-23. Loudoun County Potential Pollution Sources in NF Catoctin Creek watershed

Table 3-16. Summary of Loudoun County Potential Pollution Sources Data Layer

Code	Potential Pollution Sources	Number
PCEM	Cemetery	7
PSBD	Building (e.g. barn)	3
PSCS	Chemical storage tank	14
PSSD	Sewage disposal system	717
PSTP	Sewage treatment plant	6
WWCO	Community well	8
WWDH	Dry well	52
WWDU	Dug well	16
WWHP	Heat pump well	5
WWIN	Individual well	684
WWIR	Irrigation well	4
WWNC	Non-community well	4
WWSP	Spring	44
WWTS	Test well	228
WWUN	Unknown	4

A second map shown in Figure 3-24 was created using the floodplains data layer and the Loudoun County Open Space Easements data layer. This layer contains permanent open space easements for Loudoun County that shows both full and partial (where possible) parcel easements that currently exist. An open space easement is a legal agreement the property owner makes that restricts the type and amount of development that may take place on the property.

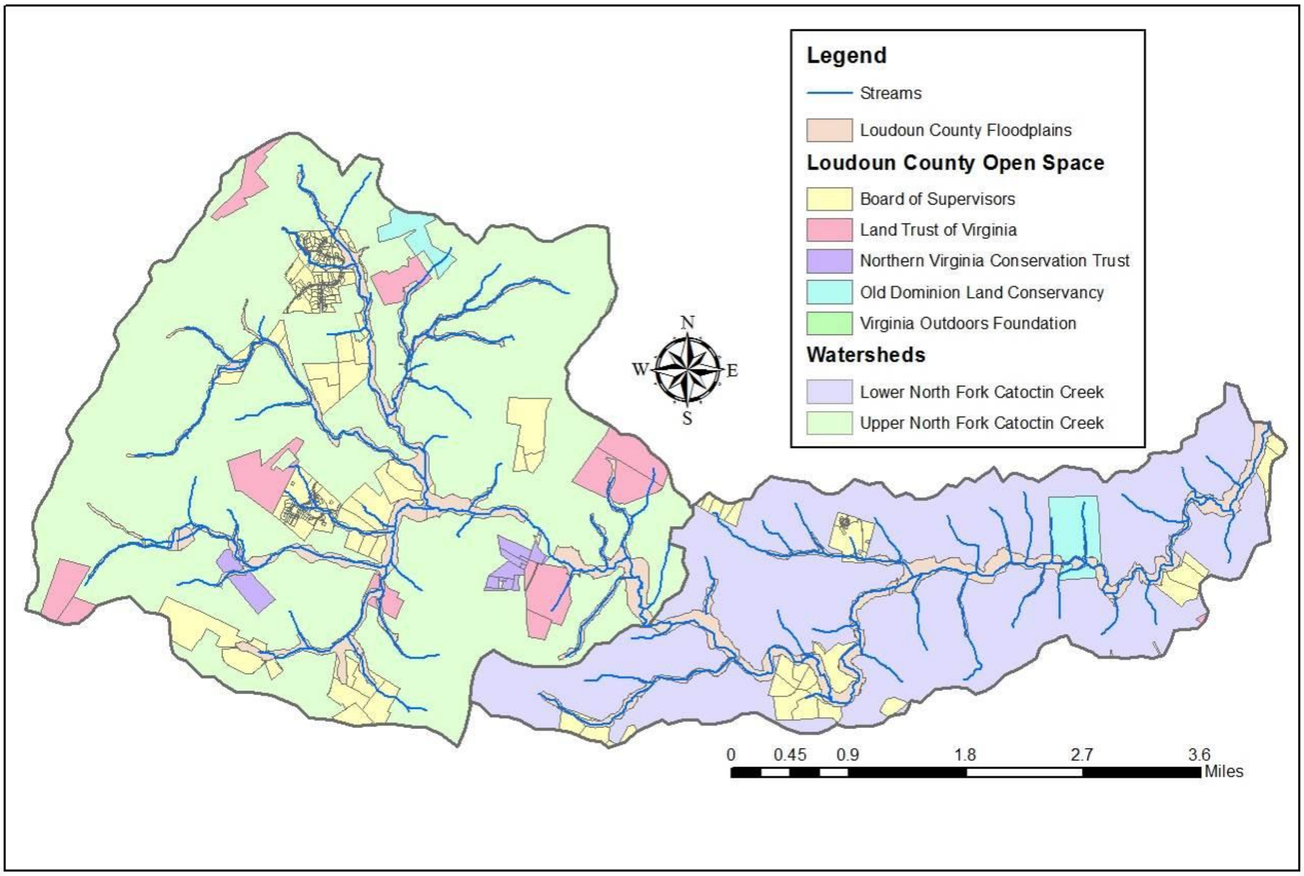

Figure 3-24. Loudoun County Floodplain and Open Space Easements

3.15. Water Resources Monitoring Program (Loudoun County, 2014)

Groundwater is the source of drinking water for most of Loudoun County outside of Loudoun Water's central service area and the Town of Leesburg. Information on groundwater quality was obtained from several sources. Before new potable water wells can be used, they must be tested and pass drinking water quality standards for a wide range of chemical parameters listed by the County Health Department. In 2013, groundwater samples that were collected and analyzed from new wells were generally consistent with historical data (Table 3-17). There are some areas of the county that have elevated levels of iron and manganese which are aesthetic contaminants and do not adversely affect human health at the concentrations found in the county. In general, groundwater quality in the county is good.

Table 3-17. Loudoun County New Groundwater Well Samples

Analyte	MCL(mg/L)	Samples		# above MCL	% above MCL
Nitrate	10	*All*	3544	15	0.4
		2013	203	0	0.0
Sulfate	250	*All*	3544	14	0.4
		2013	203	1	0.5
Lead	0.015	*All*	3547	37	1.0
		2013	203	4	1.9
Fluoride	4	*All*	3544	7	0.2
		2013	203	0	0.0
Arsenic	0.01	*All*	3551	16	0.5
		2013	203	0	0.0
Manganese	0.05*	*All*	3551	2310	65.1
		2013	203	147	72.4
Iron	0.3*	*All*	3567	2429	68.1
		2013	203	143	70.4
TDS	500*	*All*	3546	26	0.7
		2013	202	3	1.5

* Secondary MCL for taste, color, and odor.

The most prevalent sources of potential groundwater pollution are the on-site wastewater treatment systems (OWTS) serving homes and small businesses in the rural areas of the county. There are approximately 15,000 active OWTSs in the county and during 2013, 86 new OWTSs were installed. An OWTS that is properly installed and serviced should not pose a threat to groundwater quality. However, improper OWTS installation or maintenance can cause wastewater to be untreated or undertreated and lead to groundwater or surface water contamination. Because OWTSs are typically used in areas with private water wells, it is important to properly maintain the OWTS and regularly have the well water sampled and tested to assure that it is safe to drink.

3.16.Loudoun County 2009 Stream Assessment

Several citizen volunteer groups and government agencies have been conducting stream monitoring throughout Loudoun County for several years. In 2004, Loudoun Watershed Watch presented one of the first countywide comprehensive stream monitoring strategy reports.

In 2005, Loudoun Watershed Watch summarized their findings in the State of the Streams report. Many of the suggestions were further discussed and solidified during several of the Strategy for Watershed Management Solutions (SWMS) meetings held in 2006.

In 2009, a county wide stream assessment was conducted in Loudoun County. This 2009 Loudoun County stream assessment project provided comprehensive countywide information on the general health of the streams. The Department of Building Development contracted field surveys to an environmental consulting firm. The project was partially funded by a grant from the U.S. Environmental Protection Agency (EPA) and was completed in October 2009. The county wide stream assessment included inventories and analysis of benthic macroinvertebrate organisms (12 sites along NF Catoctin Creek), physical and habitat characteristics of the stream, including channel cross section, amount of sediment on the stream bed, obstructions, water depth and velocity, bank stability, and vegetation on the bank and adjacent to the stream, as well as water quality field measurements (temperature, pH and specific conductivity) at 23 sites along NF Catoctin Creek (http:// http://www.loudoun.gov/streamassessment). An overview of the benthic and habitat ratings from this survey in NF Catoctin Creek watershed is shown in Figure 3-25.

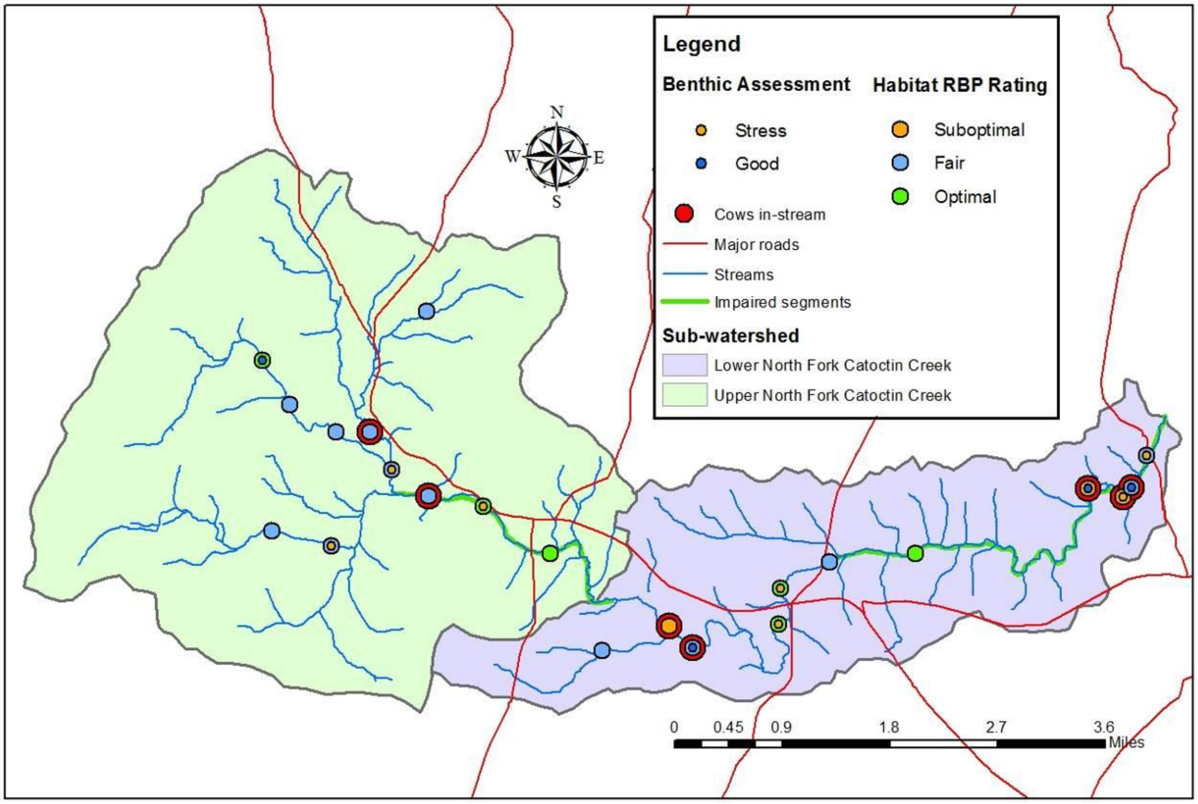

Figure 3-25. 2009 Stream Assessment Monitoring Sites with Benthic and Habitat Ratings

3.17.Local TMDLs and Implementation Efforts

The North Fork Catoctin Creek watershed was included in the 2002 bacteria TMDL for the entire Catoctin Creek watershed. Subsequent to the TMDL, an implementation plan (IP) was developed by MapTech, Inc. in 2004. The Loudoun Soil and Water Conservation District received a grant to begin implementing practices as called for in the implementation plan. §319 grant funding was secured through the Virginia Department of Conservation and Recreation and the Virginia Department of Health to allow implementation of the plan between 2004 and 2009.

The following information was excerpted from the 2010 Final Report on the Catoctin Creek TMDL IP (van Vlack and Tolley, 2010).

> *"In the years since the plan was developed, the level of development in the watershed has increased. Most of the development has been residential in nature and has involved subdivision of larger agricultural tracts to either small "farmettes" or traditional residential suburban lots."*
>
> *The Executive Summary of the TMDL implementation plan developed by MapTech called for a number of steps to be taken to meet the TMDL goal:*
>
> - *All livestock must be excluded from streams within all impairments;*

- *All straight pipes must be identified and corrected within all impairments;*
- *Implicit in the requirement for correction of straight pipes is the need to maintain all functional septic systems;*
- *Reduce wildlife direct deposition…, and*
- *Human-induced fecal coliform sources will be addressed in phased implementation of the IP, setting aside any reduction of wildlife.*

After the development of the Implementation Plan, the watershed continued to see extremely high rates of suburban and even urban growth as Loudoun continued to be one of the fastest growing counties nationwide. A succession of changes in county zoning requirements meant minimum lot subdivision sizes went from 10 acres to only 3 acres in rural areas for a period of time during the TMDL Implementation. A number of large farms in the watershed were sold and subdivided into building lots during this time. Virtually all of these lots were served by onsite well and septic systems. Consequently the number of cattle in the watershed has declined and the number of humans has increased. Equine numbers are harder to track but indications are that horses probably match or outnumber cattle in the Catoctin Watershed as of 2009. The human population of Catoctin Watershed according to the Loudoun County Demographer is estimated to be 15,128 in 2010.

At the time of the writing of the Implementation Plan, Map Tech proposed the need for 83 Cattle Exclusion Systems, 43 Horse Exclusion Systems, and 76 Hardened Crossings to complete the TMDL Implementation. The Implementation Plan divided these goals out evenly over the 5 years of proposed implementation.

TMDL Agricultural Implementation Accomplishments

During the five years of the TMDL Implementation, 51 cost share practices have been installed as part of the Catoctin TMDL Program. Thirty-seven (37) of these were animal stream exclusion practices and the remaining 14 were cover crop practices (winter cover or cropland conversion to grass). Two hundred sixty-one (261) farm visits were undertaken and 71 educational and training events were either conducted or attended by the TMDL Agricultural Specialist. Four hundred ninety-one (491) animals were excluded from streams as part of the project and $118,274.48 in TMDL funds were spent to install the agricultural practices. Eighty-two cost share practice contracts were written, although some subsequently cancelled for a variety of reasons including lack of funds to pay the landowner share, and property sales. Information on personnel expenses linked to the Catoctin TMDL Ag Program can be found in the Attachment B sections of the quarterly reports sent to the Department of Conservation and Recreation.

TMDL Residential Implementation Accomplishments

During the five years of the TMDL Implementation, a total of 47 residential practices have been installed with funding from the Catoctin TMDL program. One of these was for connection to public sewer (RB-2). Nineteen (19) were for minor repairs (RB-3) to existing sewage disposal systems (SDS). Twenty-seven (27) were for replacement of existing SDS. Ten of the twenty-seven were for replacement of existing SDSs by way of alternative SDS (RB-5). The total cost of these practices was $554,718.37. The total cost-share for these same practices was $274,783.24. Eight straight pipes were eliminated during that time, five of them replaced with systems financed with grant money. Three determined to proceed without funding.

Two stream walks were helpful; one in conjunction with a survey of discharging systems and a stream canoe trip was employed. Most projects came from Health Department staff referrals.

The latest review of water quality indicates that there has not been a sufficient reduction in fecal matter to be able to remove the watershed from the list of impaired waterways. There is a general lack of concern by the general population within the watershed over the status of the stream. This may be attributed to the general lack of use as a recreational water body. Occasionally children who live on the stream may play in the water and there are a few who canoe or kayak the stream on occasion. It has no bathing beach, boat access, or other feature to generate recreational use. As the area becomes more populated, the pastoral sight of wildlife in the stream setting may be all that is desired. A change of the designated use should be considered and evaluated.

Contributions and Successes

The program has been instrumental in raising the awareness level of landowners in the watershed of the contribution of their Sewage Disposal System (SDS) to stream health. Many landowners only had a partial understanding of the fact that their SDS could introduce pollutants to a water body that was not readily visible as well as the need to have their system regularly attended to.

The 47 residential systems represent approximately 4 million gallons per year of properly treated sewage provided through the grant program. Problem areas were uncovered during the course of the TMDL program. They were then solved by use of grant money. A cluster of houses near Hillsboro, for example, had unsatisfactory SDS's replaced for a population that was on fixed-income and really would not have been able to help themselves. The solution for that population, due to the high initial capital cost of either a conventional or alternative system replacement, would have been to employ what normally is the repair of last resort, "pump and haul". A "pump and haul" is a holding tank (the same as a septic tank but without an outlet) which is installed. The owner then has it pumped and hauled to a wastewater treatment plant every time it becomes nearly full. It is cheap capital cost that, in the long run, costs much more than the permanent on-site solution used to serve these citizens. People on low fixed income were given greater funding than other populations due to the grant program.

During a stream walk through the town of Hillsboro, a number of failing alternative discharging sewage systems "STP's" were identified. Notices of violation were issued to owners and STP's ultimately were corrected thus reducing a significant load to the creek. The presence of the Health Department and the Department of Conservation and Recreation through the TMDL program was instrumental in raising the profile of those organizations in the community. The Health Department in particular is often seen in a negative manner by people who have failing drainfields or un-potable water supplies as the bad guy who is requiring them to expend money they don't think is necessary. Because of the grant program, the Department was seen in a different light, as a source of funding.

3.18. DEQ Synoptic Sampling, June 30, 2015

In December 2012, the following comment was noted by the DEQ monitor at station 1ANOC004.38 - "algae is common; slight sewage odor". During the analysis, a tributary with considerable development was noted just upstream from this station. A request was made to DEQ for a one time set of synoptic water quality samples (samples taken at the same time) that bracketed the tributary to see whether the tributary might be the potential source of the raw sewage odor. Results of the sampling conducted on June 30, 2015 are shown in Table 3-18. All of the nutrient component and *E. coli* concentrations were lower from the tributary than from the upstream and downstream NF Catoctin Creek sites. This data points to nutrient sources being further upstream, rather than from the suspected tributary. Nitrogen components were especially higher at the NF Catoctin Creek sites, although the dissolved oxygen concentration was lower and the specific conductance value was higher at the tributary site.

Table 3-18. Nutrient Monitoring results near Wheatland, June 30, 2015

Parameter Name	Temperature	pH	Dissolved Oxygen	Specific conductance	Ammonia-N	Nitrite-N	Nitrate-N	TKN	Total Phosphorus	Orthophosphate-P	*E. coli*	
Units	°C		mg/L	µS/cm	mg/L						cfu/100 mL	
1ANOC004.38	21.5	7.07	7.77	139	0.050	0.020	0.920	0.600	0.070	0.030	243	downstream
1AXNX000.01	22.0	7.09	5.98	279	0.030	0.004	0.140	0.400	0.050	0.020	86	tributary
1ANOC004.98	22.1	7.21	7.92	135	0.050	0.030	0.910	0.700	0.070	0.030	464	upstream

4.0 DEQ's Freshwater Probabilistic Monitoring – Relative Risk Stressor Condition Classes

DEQ assesses biological condition using aquatic organisms as indicators of stream health. Impairments to the biological condition may be caused by stressors like streambed sedimentation, habitat disturbance, and nutrients, which are not subject to water quality criteria. To assist in interpreting some of these related water quality parameters, screening values (non-regulatory thresholds) are often used. DEQ is in the process of deriving screening values from its Probabilistic Monitoring (ProbMon) database, as listed in the Draft 2014 305(b)/303(d) Integrated Report and as shown in Table 4-1. The two threshold categories shown in the table have an intermediate classification of "fair" (VDEQ, 2014), and are used to help put values from this analysis in perspective.

Table 4-1. DEQ ProbMon Screening Value Categories for Parameters without Water Quality Criteria

DEQ Stressor Parameters	Alternate Name	Units	Suboptimal	Optimal	Reference
Total Nitrogen	Total Nitrogen	mg/L	>2	<1	VDEQ, 2006a
Total Phosphorus	Total Phosphorus	mg/L	>0.05	<0.02	VDEQ, 2006a
Habitat Degradation	Total Habitat Score	unitless	<120	>150	USEPA, 1999
Streambank Sedimentation	LRBS siltation Index	unitless	<-1.0	>-0.5	Kaufmann, 1999
Ionic strength	TDS	mg/L	>350	<100	VDEQ, 2006b
Metals Water Column	Metals Cumulative Criterion Unit (CCU)	unitless	>2	<1	Clements, 2000

Available data from monitoring stations in the lower and upper NF Catoctin Creek watersheds were compared with these various screening values in Table 4-2 and Table 4-3, respectively. Average values were calculated for as many of the 6 parameters given the data available at each monitoring station (3 along lower NF Catoctin Creek and 3 along upper NF Catoctin Creek). During the analysis, a break was noted in the available data at the beginning of 2006, therefore the data were summarized and the relative risk assessment was applied to the "pre-2006" and "2006-2014" data separately. The number of samples of each parameter at each site is also provided in the tables, as are summary statistics at the bottom of each table that show the number of parameters in each rating category for each station.

In the lower NF Catoctin Creek, "Optimal" stressor ratings were given for TDS, TN and CCU at the outlet station (1ANOC000.42), although each of these was based on only 1 or 2 samples. "Suboptimal" ratings at the same site were given for TP and Total Habitat. Further upstream in the lower watershed, the TN concentrations increased, the TP concentrations decreased at the next upstream site (the 2 samples at the upstream site were below the historic minimum detection limit of 0.1 mg/L), and the LRBS showed "Optimal" conditions at the middle station. In contrast, in the upper NF Catoctin Creek, the Total Habitat and LRBS ratings were "Optimal" at the one biological station (1ANOC009.37) and the average TN and TP concentrations were lower than at the lower NF Catoctin Creek stations, with the exception of the 1 sample at the farthest upstream station which was also below the minimum detection limit. Also note that all of the TN and TP data at the upper sites were "pre-2006". Note that there were different amounts of data and data from different periods available at each site, so the summary statistics at the bottom of each table are not directly comparable with other sites. Also, because of the use of two time periods, the total number of metrics in the Summary Statistics portion may be greater than the 6 parameters in this set.

Table 4-2. ProbMon Stressor Ratings for DEQ Stations in the lower NF Catoctin Creek Watershed

Parameter	Units		1ANOC000.42		Condition Class	1ANOC004.38		Condition Class	1ANOC007.28		Condition Class
			average	no. of samples	Average	average	no. of samples	Average	average	no. of samples	Average
Total dissolved solids (TDS)	mg/L	pre-2006									
		2006-2014	70.00	1	Optimal						
Total nitrogen	mg/L	pre-2006									
		2006-2014	0.98	1	Optimal	1.16	12	Fair	1.35	7	Fair
Total phosphorus	mg/L	pre-2006	0.117	112	Suboptimal	0.053	7	Suboptimal	0.100	2	Suboptimal
		2006-2014	0.072	13	Suboptimal	0.048	22	Fair	0.104	7	Suboptimal
Dissolved metals Cumulative Criterion Unit (CCU)	unitless	2006-2014	0.59	2	Optimal						
Total Habitat	unitless	2006-2014	114.55	11	Suboptimal	133.75	4	Fair			
Relative Bed Stability (LRBS)	unitless	2006-2014	-0.520	1	Fair	0.586	1	Optimal			
Summary Statistics											
Suboptimal					3			1			2
Fair					1			3			1
Optimal					3			1			0
Total No. of Metrics					7			5			3

Table 4-3. ProbMon Stressor Ratings for DEQ Stations in the upper NF Catoctin Creek Watershed

Parameter	Units		1ANOC009.13		Condition Class	1ANOC009.37		Condition Class	1ANOC011.74		Condition Class
			average	no. of samples	Average	average	no. of samples	Average	average	no. of samples	Average
Total dissolved solids (TDS)	mg/L	pre-2006									
		2006-2014									
Total nitrogen	mg/L	pre-2006				1.18	11	Fair			
		2006-2014									
Total phosphorus	mg/L	pre-2006	0.037	9	Fair	0.050	11	Fair	0.100	1	Suboptimal
		2006-2014									
Dissolved metals Cumulative Criterion Unit (CCU)	unitless	2006-2014									
Total Habitat	unitless	2006-2014				158.00	4	Optimal			
Relative Bed Stability (LRBS)	unitless	2006-2014				0.247	1	Optimal			
Summary Statistics											
Suboptimal					0			0			1
Fair					1			2			0
Optimal					0			2			0
Total No. of Metrics					1			4			1

5.0 Analysis of Candidate Stressors for NF Catoctin Creek

The suspected source of the benthic impairments in the NF Catoctin Creek was listed generically as “unknown” in both the 2008 and 2014 impaired waters fact sheets. The primary DEQ monitoring stations for biological monitoring in the impaired segments are 1ANOC000.42 and 1ANOC009.37. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. The purpose of the stressor analysis is to look for a stressor(s) that may be affecting the abundance, diversity, and pollution-sensitivity of the benthic macroinvertebrates along the lower and upper portions of North Fork Catoctin Creek, and which may have led to the initial listing of the lower segment in 2008 and the upper segment in 2014. Of special interest is to look for possible explanations as to what happened between 05/06/10 and 11/02/10 that caused a severe drop in the VSCI scores on those dates from 64.1 to 26.9 at station 1ANOC000.42 and a slightly smaller drop at station 1ANOC009.37 from 74.7 to 59.7 (sampling at the third biological station did not begin until 2011). VSCI ratings for the NF Catoctin Creek suggest that its benthic community has some minor stress throughout the system, with fluctuating “healthy” and “impaired” scores at each site, although the downstream site appears to be under a bit more stress. Because of the minor nature of this impairment at both sites, it is unlikely that one stressor will stand out strongly above the others.

A list of candidate stressors was developed and evaluated for the North Fork Catoctin Creek in order to determine the pollutant(s) responsible for the benthic impairments. A potential stressor checklist was used to evaluate known relationships or conditions that may show associations between potential stressors and changes in the benthic community. Depending on the strength of available evidence, the potential stressors were “eliminated”, considered as “possible” stressors, or recommended as the “most probable” stressor. Candidate stressors included ammonia, pH, hydrologic modifications / flow, temperature, metals, toxic organic compounds, nutrients, organic matter, sediment, and ionic strength. The evaluation of each candidate stressor is discussed in the following sections.

5.1. Eliminated Stressors

5.1.1. Ammonia

High values of ammonia are toxic to many fish species and may affect the benthic community as well. Of the 48 samples collected at five DEQ stations during 2000-2014, 33 were less than 0.04 mg/L, the minimum detection limit (MDL) or below the analysis method quantification limit. The maximum recorded value was 0.26 mg/L and no sample exceeded the chronic pH- and temperature-dependent criterion. There were no upstream point sources and no reported fish kills that might point to ammonia as a possible stressor. Therefore ammonia was eliminated from further consideration as a stressor for both the upper and lower impaired segments on NF Catoctin Creek.

5.1.2. Metals

Increased metals concentrations lead to low diversity and low total abundance of benthic organisms, with specific reduced abundance of metal-sensitive mayflies and increased abundance of metal-tolerant chironomids (Clements, 1994). Although elevated levels of manganese and iron are quite common throughout the watershed, they are regarded as a taste and odor nuisance problem, but not one that would affect benthic macroinvertebrate organisms. Two full water column samples were analyzed at station 1ANOC000.42 for a full suite of dissolved metal parameters and one earlier sample was analyzed for only four metal types. None of the dissolved metals concentrations in the any of the samples exceeded any known aquatic life or human health criteria; and the cumulative metals index for both samples was well below the threshold of concern (Clements, 2000). Therefore, metals were eliminated from further consideration as a possible stressor.

5.1.3. pH

Benthic macroinvertebrates require a specific pH range of 6.0 to 9.0 to live and grow. Changes in pH may adversely affect the survival of benthic macroinvertebrates. Treated wastewater, mining discharge and urban runoff can potentially alter in-stream levels of pH. Although historically (1980's and 1990's), there were several exceedances of the water quality standards, since 2000, all pH samples reported by DEQ at various sites around both the upper and lower portions of NF Catoctin Creek fall with the acceptable range of pH values and no in-stream pH exceedances were reported at any of the DEQ monitoring stations. Therefore, pH was eliminated from further consideration as a stressor.

5.1.4. Temperature

Elevated temperatures can stress benthic organisms and provide sub-optimal conditions for their survival. Both impaired segments along NF Catoctin Creek are classified as Class III Non-Tidal Waters (Coastal and Piedmont Zones) with a maximum temperature standard of 32°C. No exceedances of the temperature standard were recorded at any of the DEQ ambient monitoring stations. Although there is evidence that vegetation within the riparian corridor is sparse in some spots, which could lead to increased temperatures, the temperature data does not support any impact. Therefore, temperature was eliminated as a stressor.

5.1.5. Toxic Organic Compounds

Toxic substances by definition are not well tolerated by living organisms. The presence of toxics as a stressor in a watershed may be supported by very low numbers of any type of organisms, low organism diversity, exceedances of freshwater aquatic life criteria or consensus-based Probable Effect Concentrations (PEC) for metals or inorganic compounds, by low percentages of the shredder population, reports of fish kills, or by the presence of suspected sources. The one minor reported fish kill was localized to an individual pond. Although the shredder population was occasionally low at DEQ station 1ANOC000.42 (4 out of 11 samples had populations comprised of less than 2% shredders), organism diversity overall was quite good, fish have been reported above station 1ANOC009.38 in the 2000-2003 SVAP analysis, and fish redds were observed just upstream from station 1ANOC004.38. Low shredder populations could also be accounted for by poor habitat or excessive sediment. There were no sediment organic compounds tested in the three sediment samples, as there were no suspected sources of these compounds in the watershed. Therefore, since most of the potentially supporting evidence for toxicity can also be explained by other causes, and because no direct evidence of toxicity could be found (such as absence or very low numbers of organisms), toxic organic compounds have been eliminated as a possible stressor.

5.2. Possible Stressors

5.2.1. Ionic Strength

Total dissolved solids (TDS) are the inorganic salts, organic matter and other dissolved materials in water. Elevated levels of TDS cause osmotic stress and alter the osmo-regulatory functions of organisms (McCulloch et al., 1993). There was only one TDS measurements reported at any of the DEQ monitoring stations (70 mg/L at 1ANOC000.42 on 05/01/07), which is within the DEQ freshwater probabilistic monitoring (ProbMon) “optimal” range of < 100 mg/L (VDEQ, 2006a; VDEQ, 2014). The specific conductivity measurements at the various DEQ stations range generally between 100 and 250 µmhos/cm, with one outlying value of 350 µmhos/cm at station 1ANOC000.42 on 04/09/08. Although there is no specific conductivity water quality criterion, these values are relatively low in comparison to screening values used to identify reference watersheds during development of the VSCI (< 500 µmhos/cm; Tetra Tech, 2003). However, their increasing trend over time (see Figure 3-4) indicates a change in the system, which may contribute to the change in the benthic macroinvertebrate community, and thus is listed as a possible stressor.

5.2.2. Nutrients

Excessive nutrient inputs can lead to increasing algal growth, eutrophication, and low dissolved oxygen (DO) concentrations that may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration. Sources of nitrogen include groundwater, residential wastewater, atmospheric deposition, and agricultural activities. Although there are no state water quality criteria for nutrients in free-flowing surface waters, Loudoun County (2014) compares its samples with the 2000 EPA nutrient guideline thresholds of 0.69 mg N/L and 0.037 mg P/L. Compared to these thresholds, 97% (n=31) of the dissolved N and 75% (n=61) of the dissolved P samples at the 5 stations along NF Catoctin Creek exceeded these thresholds, compared with county-wide averages of 85% and 41%, respectively. Therefore, both N and P concentrations are elevated relative to the county as a whole. The EPA threshold values are quite stringent, have not been deemed appropriate by Virginia, and are much lower even than ProbMon screening “sub-optimal” breakpoint values of 2.0 and 0.05 mg/L for N and P, respectively (VDEQ, 2006a; VDEQ, 2014). Nutrient-loving chironimidae and hydropsychidae organisms were dominant in the majority of samples at all 3 biological monitoring sites, although most of the samples were quite diverse, many with an equal abundance of pollutant-sensitive organisms. In addition to the sufficiency of nutrients in the streams, one excursion of the dissolved oxygen criteria has been noted at 1ANOC000.42 – a concentration of 2.5 mg/L on 08/10/11, during low flow conditions.

There may have been limited historical applications of biosolids in the watershed, but there are no recent active permits in the watershed. There are currently 717 septic systems in the watershed, which is expected to increase with future development. Although many landowners have participated in recent Loudoun County Soil and Water Conservation District (SWCD) implementation under the 2004-2009 §319 grant, there are livestock with direct access to the stream, including one property just upstream from station 1ANOC000.42 observed by DEQ monitors in October 2009 and by the project contractor in May 2015. Seven locations throughout the watershed were reported with cows in the stream during the 2009 Loudoun County stream assessment. On 12/03/12 at station 1ANOC004.38, the local DEQ biological monitor noted: "algae is common; slight sewage odor". Nitrate-N, TKN, orthophosphate-P (dissolved) and total P concentrations are all lower than 30 years ago, though sampling between 2001 and 2012 was very sparse. There is no detectable increase in nitrate-N that would correlate with the increased number of septic systems in the watersheds, and nitrate in drinking water samples are the same order of magnitude as the current stream samples. There does appear to be a trend of higher dissolved N in the winter months and higher dissolved P in the summer months, though no sources have been directly associated with these trends. Average TN concentrations at 2 of the 3 stations on the lower NF Catoctin Creek and at one station on the upper NF Catoctin Creek rated "fair" by the ProbMon condition class ratings; the third station on the lower NF Catoctin Creek was rated as "optimal". The average TP concentrations at all three stations on the lower NF Catoctin Creek and at one station on the upper NF Catoctin Creek were rated "suboptimal" by the ProbMon condition class ratings. All of the ratings in the upper NF Catoctin Creek, however, were based on 10-year old data. Nutrient levels are elevated in both impaired segments of the NF Catoctin Creek, but to a greater extent in the lower NF Catoctin Creek segment, which also may have been related to the one low DO measurement in conjunction with low flow on that date. Therefore, nutrients were determined to be a possible stressor to the biological community in both the upper and lower NF Catoctin Creek segments, with slightly greater impacts being observed in the lower segment.

5.2.3. Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter in NF Catoctin Creek include household wastewater discharges, spills, malfunctioning septic systems, livestock, and runoff from impervious areas. Organic enrichment in both the upper and lower NF Catoctin Creek is supported by the types of abundant benthic organisms found in many of the samples – hydropsychidae and chironomidae – typical of organic-enriched sites, and the occasional presence of asellidae and oligochaete organisms. In support of excessive organic matter are high metric values of the Modified Family Biotic Index (MFBI) metric (>5.00) that occurred in 6 of the 11 samples at 1ANOC000.42 in the lower NF Catoctin Creek, but in none of the 4 samples taken at each of the other two biological stations (see ‘FamHBI’ metric in Table 1-3 and Table 1-4). Reductions in the scraper functional group of organisms are shown by low values of the scraper/filterer-collector ratio (< 0.5) (see Tables 1-1 and 1-2) that occurred in 17 of 19 samples from all sites, and the average ‘% of filterer-collectors’ metric was above 50%, indicative of the availability of suspended fine particulate organic matter. Only a limited number of 5-day biological oxygen demand (BOD_5) readings (11) had been recorded, but of those, only one sample was recorded with a value that was above the limit of detection or the method quantification limit. Two DO values below 5 mg/L have been recorded out of 88 samples from 5 different DEQ ambient monitoring sites – 4.7 mg/L at 1ANOC007.28 on 08/24/06 and 2.5 mg/L at 1ANOC000.42 on 08/10/11, both coinciding with low flow conditions. The TKN:TN ratios indicated only low (upper NF) to moderate (lower NF) levels of organic N at the three ambient stations with sufficient data. The abundance of septic systems and livestock with stream access also represent potential sources of organic matter to the system. Therefore, elevated levels of organic matter may contribute to the impairment on the lower NF Catoctin Creek, although less evidence is available to support a finding of stress to the upper NF. In the absence of current supportive BOD_5, chemical oxygen demand (COD), or DO evidence for organic matter impacting the benthic communities, organic matter was considered as a possible stressor in both the upper and lower NF Catoctin Creek segments, similar to nutrients, with slightly greater impacts being observed in the lower segment.

5.3. Most Probable Stressors

5.3.1. Hydrologic Modifications

Hydrologic modifications can cause shifts in the availability of water, sediment, food supply, habitat, and pollutants from one part of the watershed to another, thereby causing changes in the types of biological communities that can be supported by the changed environment. A USGS flow monitoring gage is located at the Rt. 681 bridge near the outlet of the watershed and coincident with DEQ monitoring station 1ANOC000.42. There appears to be a correspondence between biological VSCI scores at the DEQ station and 60-day mean flow measured by USGS, as shown in Figure 5-1.

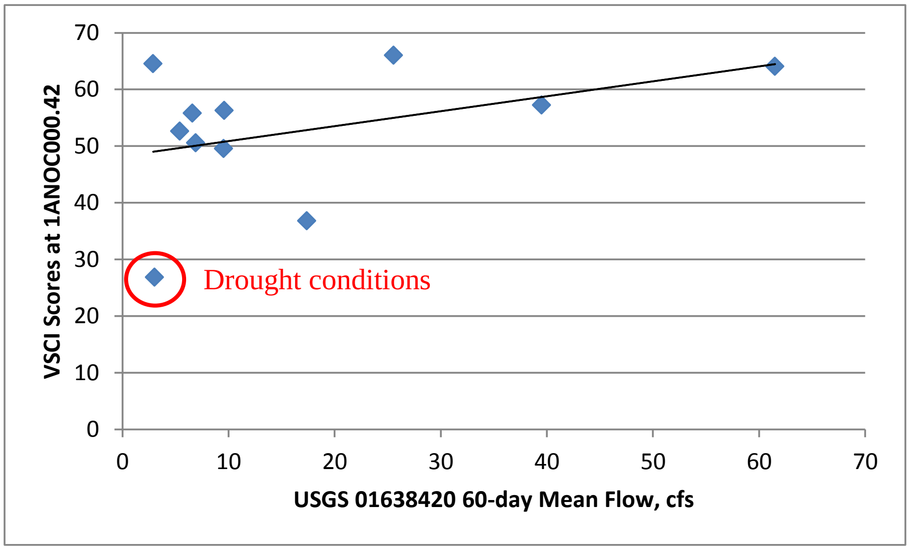

Figure 5-1. Correspondence between VSCI Scores and 60-Day Mean Flow

Additional evidence for flow being a most probable stressor comes from both anecdotal information and from analysis of no-flow days with the occurrence of poor VSCI scores. On 11/02/10, DEQ monitors noted "drought conditions" at both station 1ANOC000.42 (lower NF Catoctin) and station 1ANOC009.37 (upper NF Catoctin), which coincidentally corresponded with a large decrease in VSCI scores at both sites and the worst VSCI score ever at 1ANOC000.42 (circled in red in Figure 5-1). Analysis of daily flow monitoring at the USGS 01638420 site at Rt. 681 since April 2000 indicated an average of 10.5 days per year with no flow (Loudoun County, 2014). Additional analysis (in Table 5-1), however, revealed that these no-flow days all occurred during three periods and that VSCI scores experienced large decreases in fall and spring samples immediately following Aug-Oct periods with clustered no-flow days. Although several stations were not sampled at times that could have further corroborated this pattern (shown as NS in Table 5-1), no exceptions were shown to this pattern during the monitoring period. Note that VSCI monitoring in the watershed only began in Spring 2006 at station 1ANOC000.42 and at later dates at the other NF Catoctin Creek stations. Genetic programming in benthic organisms is known to cause the organisms to enter self-induced periods of dormancy (also known as diapause) when faced with extreme environmental conditions, such as extended low-flow or no-flow conditions (Voshell, 2002), which could explain the large shift in the benthic community following the extended observed periods of no-flow.

Table 5-1. Correspondence of No-Flow periods with Large Decreases in VSCI Scores

Year	No. Days with No Flow	Dry Months	VSCI Scores					
			1ANOC000.42		1ANOC004.38		1ANOC009.37	
			Spring	Fall	Spring	Fall	Spring	Fall
2001	0							
2002	**37**	Aug, Sept						
2003	0							
2004	0							
2005	0							
2006	0		49.5	66.0				
2007	**47**	Sept, Oct	57.2	NS				
2008	0		**36.8**	50.6				
2009	0		55.8	64.5				
2010	**26**	Sept	64.1	**26.9**			74.7	**59.7**
2011	0		NS	56.3		61.7	NS	55.6
2012	0		NS	NS	66.1	65.4	NS	NS
2013	0		NS	NS	NS	NS	NS	NS
2014	0		NS	52.6	NS	51.8	NS	59.0

NS = no sample taken, after the initiation of biological monitoring at each site.

Values are high-lighted in red for Fall and Spring samples that followed no-flow periods.

Hydrologic modifications in the NF Catoctin Creek watershed include 8 dams, about 1,000 groundwater wells, increasing development and associated impervious areas, and significant surface water withdrawals by the Town of Purcellville (see Figure 3-17). Data presented by consultant CH2M Hill to the Loudoun County Water Resources Technical Advisory and Loudoun Watershed Management Stakeholder Steering Committees in 2007 indicated that the NF Catoctin Creek watershed had a relatively low groundwater residual under drought conditions (see Figure 3-21). Since 2009, the surface water withdrawals by the Town of Purcellville have been declining and the demand replaced with well water. An increasing trend in annual flow corresponds with the decreasing withdrawals (Figure 5-2).

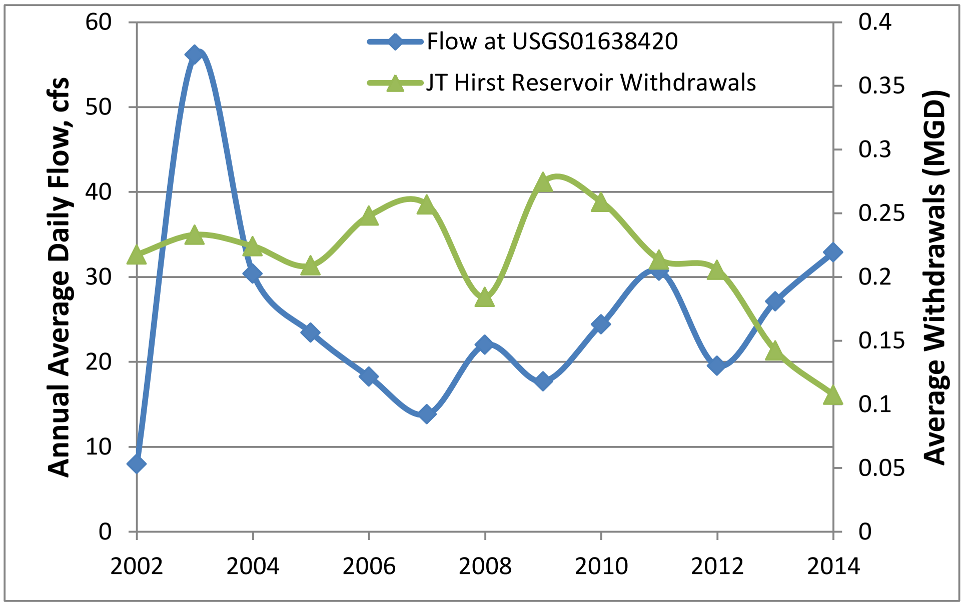

Figure 5-2. Decreasing Water Withdrawals vs. Increasing Annual Flow since 2009

Therefore, hydrologic modifications and climate variability appear to be the "most probable" stressor contributing to observed decreases in the health of the benthic macroinvertebrate community in both impaired segments of NF Catoctin Creek.

While recent decreases in surface water withdrawals appear to increase average annual flows and may alleviate drought conditions somewhat, the pressure put on the watershed through the large number of groundwater wells, increasing development and impervious surface area, and increasing climate variability may all continue to be a source of stress on the benthic community.

5.3.2. Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forestry and agricultural runoffs, livestock access to streams, construction sites, and in-stream disturbances. There appear to be healthy populations of haptobenthos (organisms that require clean, coarse substrates) in all but the 2 samples at 1ANOC000.42 that followed clustered no-flow periods. Likewise, habitat embeddedness metrics were only poor in 1 sample each at stations 1ANOC000.42 and 1ANOC004.38, although embeddedness measured in conjunction with the LRBS sampling was elevated at 1ANOC000.42, as shown in Table 5-2. For this summary, station 1ANOC000.42 represents the "Upper", 1ANOC004.38 represents the "Mid", and station 1ANOC009.37 represents the "Lower" sections of the North Fork Catoctin Creek.

Table 5-2. Sediment-related Habitat and LRBS metrics and 2009 observations of "Cows in-stream"

Metric	Upper	Mid	Lower
Habitat "poor" or "marginal"			
embeddedness	0/4	1/4	1/11
bank stability	0/4	3/4	9/11
vegetative protection	0/4	0/4	9/11
riparian vegetative zone width	2/4	0/4	10/11
sediment deposition	0/4	2/4	10/11
LRBS Siltation Index metrics			
percent sand & fines	11%	19%	53%
embeddedness	44%	54%	76%
LRBS rating	optimal	optimal	fair
livestock in-stream	2	2	3

The habitat embeddedness metric at station 1ANOC000.42 presented a fairly low impact picture of the site. However, out of 11 samples, habitat metrics were poor or marginal for bank stability and vegetative protection metrics in 9 samples each, and for riparian vegetative zone width and sediment deposition metrics in 10 samples each. In the upper NF Catoctin Creek, the only poor or marginal ratings for the same metrics at station 1ANOC009.37 were 2 out of 4 samples for riparian vegetative zone width. There was the occasional sample with elevated TSS or turbidity concentrations associated with a runoff event, but TSS was typically less than 20 mg/L. The LRBS siltation index values recorded in November 2014 for stations 1ANOC009.37, 1ANOC004.38, and 1ANOC000.42 were rated as "optimal", "optimal", and "fair", respectively (VDEQ, 2014). Potential sources of sediment in the watershed include surface runoff, especially from new construction and increasing amounts of impervious surfaces, some bank erosion, and livestock access to streams. Based on a series of annual aerial photos from the Loudoun County online archives, Godfrey Lake appears to have been drained at some point prior to 2002, which could have introduced a large amount of stored sediment back into the stream system, prior to the dam being rebuilt several years later. Some potential sources may also have been mitigated through accelerated implementation of cover crop and stream exclusion fencing in the watershed by the Loudoun County SWCD during 2005-2009 in conjunction with a §319 grant to address an ongoing bacteria impairment in the larger Catoctin Creek watershed. In the upper NF Catoctin Creek, the impacts from sediment appear to be fairly minor, and sediment is not considered a stressor. In the lower NF Catoctin Creek, the evidence for sediment as a stressor is stronger through the habitat metrics and through the various observances of livestock disturbances to the stream, including most prominently a location directly upstream from the 1ANOC000.42 monitoring point, as illustrated by the trampled streambank and the silted-in stream bottom in Figure 5-1.

Figure 5-3. Livestock stream access at 1ANOC000.42, May 2015

5.4. Summary

Overall, extended periods of no-flow appear to be the most probable stressor on both impaired segments and were implicit in the major decreases experienced between successive samples at the listing stations on both impaired segments. Reduced withdrawals by the Town of Purcellville since 2009 may be increasing stream water levels in the NF Catoctin Creek and, to a certain extent, alleviating this source of stress, although its effect on drought conditions is not yet known.

The upper NF Catoctin Creek (VAN-A02R_NOC03A02) stream segment has a minor impairment to its aquatic life use primarily due to low-flow conditions. The upper NF Catoctin Creek may be affected by slightly elevated levels of nitrogen and phosphorus, but not sufficient to warrant a TMDL. It is recommended that this stream segment be re-classified as a Category 4C water, as the impairment is not caused by a pollutant, and, therefore, no TMDL is required.

The lower NF Catoctin Creek (VAN-A02R_NOC01A00) stream segment has a slightly greater impairment to its aquatic life use that has been monitored over a longer period than the upstream site. In addition to stress brought on by extended no-flow conditions, the benthic community in the lower NF Catoctin Creek has been affected by other stressors over time, as shown by other periodic low VSCI scores during other flow regimes than no-flow periods. Sediment is the most probable additional stressor in the lower NF Catoctin Creek, although nutrients and organic matter may be additional minor sources of stress on the benthic community. Therefore, it is recommended that a TMDL be developed for sediment to address the aquatic life use impairment on the lower NF Catoctin Creek stream segment.

5.5. *Pro-active Opportunities*

In reviewing comments from DEQ monitors that accompany benthic sample data entries, it is worthy to note that their brief on-site observations directly correspond to suggested problems and courses of action implied by this analysis. These include: the impact of drought conditions (1ANOC000.42 and 1ANOC009.37), abundant algae in the stream accompanied by a strong sewage odor (1ANOC004.38), and livestock in the stream at the monitoring site (1ANOC000.42).

While reduced stream withdrawals by the Town of Purcellville show promise for increasing future stream flow and buffering drought conditions, the other observations imply immediate actions that could be taken to pro-actively address benthic stressors and to improve conditions in NF Catoctin Creek, without waiting for a TMDL or Implementation Plan. While the synoptic sampling in June 2015 did not isolate the earlier reported "sewage odor" reported at a monitoring site, additional DEQ synoptic sampling may be needed to isolate nutrient sources related to illegal sewage disposal, with sampling occurring as close to the time of observation as possible. It is suggested that DEQ partner with VDH and appropriate agencies within Loudoun County to follow up on these types of observations on a timely basis to more readily identify pollutant sources as they appear. Where livestock have direct access to streams, especially near monitoring stations that tend to amplify the reported impact, outreach efforts could be targeted to immediately address obvious problems that may improve benthic conditions and forestall the need for more widespread, expensive planning efforts. Case in point, there are approximately 8,000 linear feet of streams immediately upstream from the 1ANOC000.42 monitoring point with livestock access (see Figure 5-4).

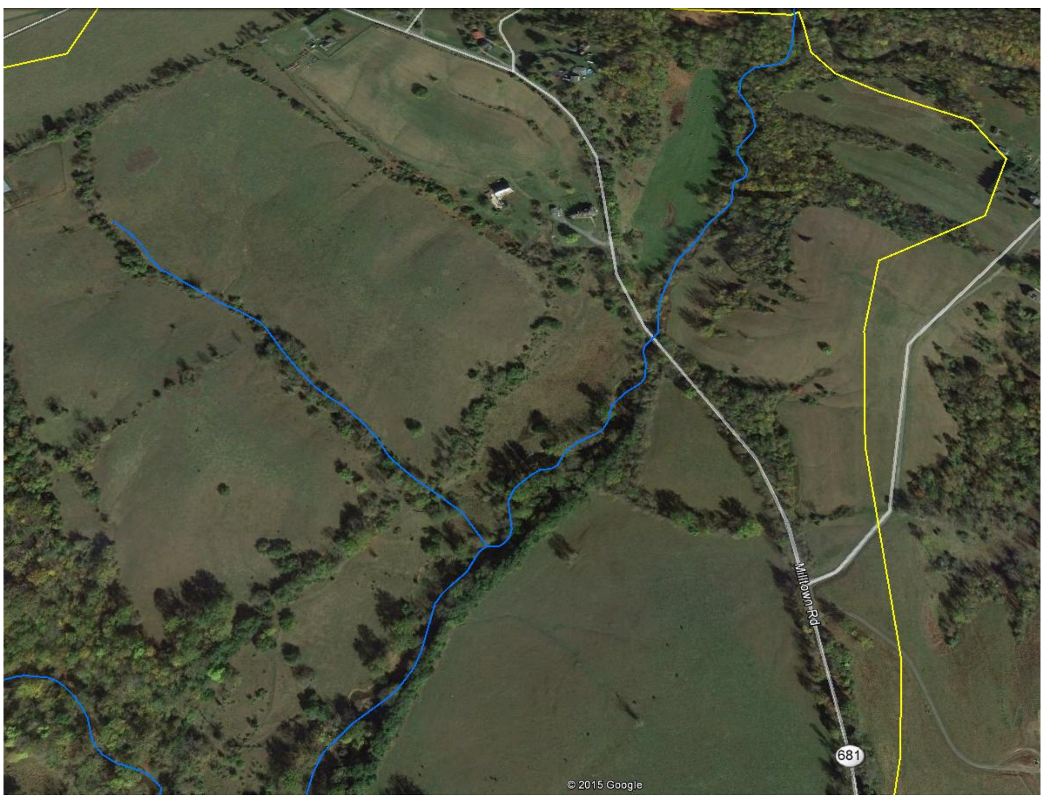

Figure 5-4. Streams immediately upstream from 1ANOC000.42 with Livestock Access

References

ACS. 2012. American Community Survey 2007-2011 5-yr Estimates. US Census Bureau. Available at: www.census.gov/acs/www/ . Accessed 2 July 2013.

Benham et al., 2013. Household Water Quality in Loudoun County, Virginia; October 2013; VCE Publication BSE-158NP. Blacksburg, VA: Virginia Household Water Quality Program, Virginia Cooperative Extension, Virginia Tech. Available at: http://pubs.ext.vt.edu/BSE/BSE-158/BSE-158.html. Accessed 14 April 2015.

Catoctin Watershed Project. Stream Monitoring. Review of historic low stream flow statistics (7Q10). Available at: http://www.loudounwatershedwatch.org/catoctin/monitor.html. Accessed 14 April 2015.

Clements, W.H., D.M. Carlisle, J.M. Lazorchak, and P.C. Johnson. 2000. Heavy metals structure benthic communities in Colorado Mountain streams. Ecological Applications 10(2): 626-638.

Clements, W.H. 1994. Benthic invertebrate community responses to heavy metals in the upper Arkansas River Basin, Colorado. J. North Amer. Benth. Soc. 13:30-44.

Dunne, T.L. and Leopold, L.B. 1978. Water in Environmental Planning. W.H. Freeman and Company, New York, 818 p.

Engineering Concepts, Inc. 2000. Water resources study. Purcellville, Virginia. March 14, 2000. Available at: http://www.purcellvilleva.gov/DocumentCenter/Home/View/150. Accessed 12 April 2015.

Loudoun County. 2008. Summary of water resource and related data in Loudoun County, VA. Loudoun County Building & Development Water Resources Team. Available at: http://www.loudoun.gov/DocumentCenter/Home/View/4824. Accessed 12 April 2014.

Loudoun County. 2014. 2013 Water resources monitoring data summary. Department of Building and Development, Engineering Division, Water Resources Team. Available at: http://www.loudoun.gov/watermonitoring. Accessed: 29 June 2015.

MapTech, Inc. Catoctin Creek Water Quality Implementation Plan (Fecal Coliform TMDLs) Executive Summary. 2004. Available at: http:// http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/catoctip.pdf. Accessed 14 April 2015.

McCulloch, W.L., W.L. Goodfellow, and J.A. Black. 1993. Characterization, identification and confirmation of total dissolved solids as effluent toxicants. In: Environmental Toxicology and Risk Assessment, 2nd Volume, STP1216. J.W. Gorsuch, F.J. Dwyer, C.G. Ingersoll, and T.W. La Point (eds.). Philadelphia, Pa.: American Society for Testing and Materials. pp. 213-227.

MWCOG. 2006. Loudoun County baseline biological monitoring survey (2004-2006). Phase II: Clarks Run, Catoctin Creek, Quarter Branch, Dutchman Creek and Piney Run Conditions. Department of Environmental Programs, Metropolitan Washington Council of Governments. Available at: http://www.mwcog.org/store/item.asp?PUBLICATION_ID=295. Accessed 14 April 2015.

Omernik, J., & Griffith, G. (2008). Ecoregions of Delaware, Maryland, Pennsylvania, Virginia, and West Virginia (EPA). Available at: http://www.eoearth.org/view/article/152020. Accessed 9 April 2015.

SERCC. 2015. NCDC 1971-2000 Monthly Normals for Lincoln, Virginia. Available at: www.sercc.com/cgi-bin/sercc/cliMAIN.pl?va4909. Accessed 9 April 2015.

Tetra Tech. 2003. A Stream Condition Index for Virginia Non-Coastal Streams. Available at: http://www.deq.state.va.us/Portals/0/DEQ/Water/WaterQualityMonitoring/vastrmcon.pdf. Accessed 31 July 2015.

Town of Purcellville, Virginia. Official Website – Drinking Water. Available at: http://purcellvilleva.com/index.aspx?NID=581. Accessed 14 April 2015.

USDA-NASS. 2012. Cropland data layer. National Agricultural Statistics Service. Available at: http://www.nass.usda.gov/research/Cropland/SARS1a.htm. Accessed 7 April 2014.

USDA-NRCS. 2012a. VA 107 – Loudoun County, Virginia. Tabular and spatial data. Soil Data Mart. U.S. Department of Agriculture, Natural Resources Conservation Service. Available at: http://websoilsurvey.nrcs.usda.gov. Accessed 10 January 2014.

USDA-NRCS. 2012b. Official Soil Series Descriptions (OSD) with series extent mapping capabilities. Available at: https://soilseries.sc.egov.usda.gov/osdname.asp. Accessed 15 April 2015.

USDA-NRCS. 2005. Aquatic condition response to buffer establishment on Northern Virginia streams. Billy Teels, Charles Rewa, and John Myers. U.S. Department of Agriculture, Natural Resources Conservation Service. Available at: http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=18518.wba. Accessed 14 April 2015.

USGS, 2015. Daily stream flow for NF Catoctin Creek (01638420) at Rt 681 near Waterford, VA. July 20, 2001 – April 12, 2015. Available at: http://waterdata.usgs.gov/nwis/dv/?referred_module=sw. Accessed 31 March 2015.

VDEQ. 2006a. Using probabilistic monitoring data to validate the non-coastal Virginia Stream Condition Index. VDEQ Technical Bulletin WQA/2006-001. Richmond, Va.: Virginia Department of Environmental Quality; Water Quality Monitoring, Biological Monitoring and Water Quality Assessment Programs.

VDEQ. 2006b. Fecal Bacteria and General Standard Total Maximum Daily Load Development for Straight Creek. Richmond, Virginia. VDEQ TMDL Study. Available at: http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/tenbigrvr/straight.pdf. Accessed 31 July 2015.

VDEQ, 2008. Final 305(b)/303(d) 2008 Water Quality Assessment Integrated Report. Richmond, Virginia.

VDEQ, 2010. Final 305(b)/303(d) 2010 Water Quality Assessment Integrated Report. Richmond, Virginia.

VDEQ, 2012. Final 305(b)/303(d) 2012 Water Quality Assessment Integrated Report. Richmond, Virginia. Available at: http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/2012305(b)303(d)IntegratedReport.aspx. Accessed 24 February 2014.

VDEQ, 2014. Draft 305(b)/303(d) 2014 Water Quality Assessment Integrated Report. Richmond, Virginia. Available at: http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/2014305(b)303(d)IntegratedReport.aspx. Accessed 17 December 2014.

VDEQ, 2015. Commonwealth of Virginia. State Water Resources Plan. Virginia SWRP – Draft. April 2015. Available at: http://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/WaterSupplyPlanning/StateWaterPlan.aspx. Accessed 16 April 2015.

VCU. InStar Healthy Waters web site. Virginia Commonwealth University, Center for Environmental Studies. Available at: http://gis.vcu.edu/instar/. Accessed 14 April 2015.

Vlack, C.V. and M. Tolley. 2010. Catoctin Creek TMDL Implementation Project. Final Report. Loudoun Soil and Water Conservation District and Loudoun Environmental Health Department. Leesburg, Va.

Voshell, J.R. Jr. 2002. A guide to common freshwater invertebrates of North America. Blacksburg, Va.: The MacDonald & Woodward Publishing Company.